California Energy Commission

Supplement to the

Five-Year Investment Plan, 2002 Through 2006

for the

Public Interest Energy Research (PIER) Program

Volume 2

Report to the California Legislature

RD&D Committee Draft, February 9, 2001

DISCLAIMER

This report was prepared for the California Energy Commission's RD&D Committee to be consistent with the requirements of AB 995 (Wright) and SB 1194 (Sher). It was accepted as the Committee's report on February 2, 2001. The report is scheduled for consideration and adoption by the full Commission on February 21, 2001. The views and recommendations contained herein are not the official position of the California Energy Commission until this report is adopted at a public meeting.

http://www.energy.ca.gov/research

Acknowledgments

Planning Team - Public Interest Energy Research Program

Alec Jenkins - Lead, PIER Program Planning and Evaluation
Mike Batham
John Beyer
Gary Klein
Mike Magaletti
Don Schwartz
Gerald Pine - GTI
Graduate Student Assistants
    Jing Chen
    Janine Flathmann
    Natalia Golotvina
Student Assistant
    Shannon Ryan

Contributors

Subject Area Leads and Staff - Public Interest Energy Research Program

Mike Batham – Environmentally-Preferred Advanced Generation
Kelly Birkinshaw – Environmental Research
    Gina Barkalow
Nancy Jenkins – Buildings Energy Efficiency
    Martha Brook
Pramod Kulkarni – Industrial, Agricultural, Water Efficiency
George Simons – Renewables
Laurie ten Hope – Strategic Research

General Counsel's Office

David Abelson

Energy Information & Analysis Division

Karen Griffin, Deputy Director (Acting)
Al Alvarado – Market Analysis and Modeling Unit

Energy Technology Development Division

Mike DeAngelis, Deputy Division Chief
Ron Kukulka, Assistant Deputy Director

PIER Program Manager

Terry Surles

RD&D Committee

Arthur H. Rosenfeld, Commissioner and Presiding Member
    John Wilson, Principal Advisor
Robert A. Laurie, Commissioner and Associate Member
    Scott Tomashefsky, Principal Advisor

Table of Contents

Section **Page**

List of Figures

List of Tables

Chapter 1 — Introduction and Guiding Principles for the PIER Investment Plan

1.1 Introduction

The California Energy Commission (Commission) has prepared this report to present the strategic approach of the Commission's Public Interest Energy Research (PIER) Program for addressing California's energy-related problems. The strategies described below will lead to solutions that can be developed through PIER research, development and demonstration (RD&D) projects to increase electricity supply, reduce demand, lower peak demand, improve reliability and power quality, improve the operation of the market, and protect and improve the environment.

This report responds to directives contained in Assembly Bill (AB) 995 (Wright) and Senate Bill (SB) 1194 (Sher), signed into law in September, 2000, which required that the Commission submit a Five-Year Investment Plan for PIER to the Legislature by March 1, 2001. It also contains our response to important concerns raised by the PIER Independent Review Panel, which was convened as directed by SB 90.

Since the original legislation establishing the PIER Program was passed (AB 1890 in 1996 and SB 90 in 1997), significant changes have impacted California's energy landscape. PIER RD&D will help to alleviate and avoid California's energy-related problems, such as those impacting the state today in this new, dynamic energy environment. PIER will adopt a portfolio approach to effectively balance the risks, benefits to ratepayers, and time horizons for various PIER activities and investments. Funding will be allocated to:

1. Advance science and engineering for a diverse range of technologies across the six PIER technical subject areas:

- Buildings End-Use Energy Efficiency
- Industrial / Agricultural / Water End-Use Energy Efficiency
- Renewable Energy
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Energy Systems (Strategic) Research.

2. Address different time frames for impact on the market and different challenges along the RD&D spectrum, from feasibility studies on new, longer-term energy concepts, to applied research, to technology development, to demonstrations.

3. Find integrated solutions for California's major energy problems.

4. Leverage PIER monies with co-funding or in-kind contributions from other private, regulated or public sector participants.

All PIER research activities will be approved for funding by the PIER Program Manager and the Commission's RD&D Committee based upon emerging opportunities, shifts in important electricity system problems, and the benefits derived from prior projects in each of the PIER technical subject areas. This will ensure that the PIER Program develops solicitations and funds projects that provide the most significant benefits to the citizens and ratepayers of California.

The topics covered in this report include:

- Guiding Principles for the PIER Program
- The California Energy Context for the PIER Program
- RD&D Strategies for Addressing California's Major Energy Problems
- The PIER Five-Year Implementation Plan and Budget for 2002 Through 2006
- Response to the PIER Independent Review Panel's Preliminary Report.

A more succinct presentation of this information can be found in the companion document, *Five-Year Investment Plan, 2002 Through 2006, for the Public Interest Energy Research (PIER) Program, Report to the California Legislature.*

1.2 Background and Purpose of this Report

In 1996, California decided to fundamentally restructure and reduce the regulation of much of this state's electricity system. To ensure that certain public goods would not be lost as a result, AB 1890 and SB 90 authorized, among other things, collection of an electricity consumption surcharge totaling $62.5 million annually from 1998 through 2001 to fund a public interest energy research program primarily administered by the Commission.

In 1998, the Commission began evaluating and funding specified energy-related RD&D activities that advance science or technologies not adequately provided by competitive and regulated markets. Guided primarily by its Strategic Plan[1], the Commission has, to date, encumbered more than $100 million in PIER funding, primarily by approving a wide variety of individual RD&D projects, programs, and research memberships in the six PIER subject areas.

In 1999, as directed by the Legislature in SB 90, an independent panel of experts initiated a two-year long evaluation of the PIER Program. The panel focused on whether PIER provides adequate benefits to California's citizens and electricity ratepayers, and if the program should be continued under Commission administration beyond the end of 2001. In March of 2000, the PIER IRP filed its preliminary report with the Legislature finding, among other things, that the type of public interest energy research efforts funded through the PIER Program are of great value to California. However, the IRP also raised concerns about the administration of the PIER Program.

In September 2000, the Legislature passed and Governor Gray Davis signed into law SB 1194 (Sher) and AB 995 (Wright).[2] Among other things, this legislation extends electricity surcharge

---

[1] Strategic Plan for Implementing the RD&D Provisions of AB 1890, California Energy Commission, June 1997, P500-97-007.

[2] These two bills are identical in their content and have been formally enacted into 2000 Statutes, Chapters 1050 and 1051, respectively.

funding for the PIER Program for an additional 10 years, from January 2002 to January 2012. The law specifically requires the Commission to file a five-year investment plan with the Legislature by March 1, 2001. The plan must address how the Commission intends to manage the PIER Program from 2002 through 2006, as well as how the Commission has responded to various issues and concerns raised by the IRP in its preliminary and final reports to the Legislature.

In response to the directives contained in SB 1194 and AB 995, and the important concerns raised by the PIER IRP, the Commission devoted significant resources to carefully preparing and publicly reviewing the PIER *Five-Year Investment Plan, 2002 Through 2006*, including this Supplement. The topics covered in each chapter of this report include:

> Chapter 1 – Background and purpose of this report, vision and mission of the PIER Program, public benefits criteria, an operational definition of public interest research, and other important PIER Program objectives.
>
> Chapter 2 – Current California context and energy-related trends and impacts that form the basis for RD&D planning.
>
> Chapter 3 – Four major energy-related problems that confronts California, and the portfolio of integrated RD&D strategies adopted by PIER for attacking these problems and finding solutions.
>
> Chapter 4 – PIER's portfolio approach to funding projects, the PIER budget and guidelines for governing budgeting flexibility, the administrative concerns raised by the IRP, actions that the Commission took to strengthen the administration of the PIER Program, and recommendations for legislative action that will facilitate efficient administration.

With effective implementation of the priorities and directions set forth in this report, the Commission believes that the PIER Program will provide significant public benefits to the citizens and ratepayers of California and will also serve as a model for sound public interest energy research programs throughout the nation and the rest of the world. We are excited about the great potential of this program, and we look forward to its implementation in the years ahead.

1.3 Vision and Mission

A Vision to Guide All PIER Program Efforts

With the previous essential foundational material in mind, we now offer the following vision statement to serve as a guidepost for the PIER Five-Year Investment Plan.

> In the future, California must provide a clean, affordable, reliable, and resilient supply of electricity where "smart," efficient customers have energy choices that can meet their individual needs, and California's industries can grow and prosper. The PIER Program will support and catalyze science and technology advancements by providing leveraged funding to establish California as the world leader in energy efficiency and clean, advanced energy technologies and systems.

Mission of the PIER Program

In 1996 and 1997, two separate Working Groups, comprised of more than 70 individuals and entities with extensive expertise and interest in public interest research, filed detailed reports with both the California Public Utilities Commission (CPUC) and the Energy Commission. These reports described, among other things, the appropriate mission for a public interest energy research effort such as the PIER Program.[3] Based on the recommendations contained in those Working Group Reports, in June 1997, the Energy Commission adopted the following Mission Statement for the PIER Program in its RD&D Strategic Plan:

> The mission of the PIER Program is to conduct public interest energy research that seeks to improve the quality of life for California's citizens by providing environmentally sound, safe, reliable and affordable energy services and products. Public interest energy research includes the full range of research, development and demonstration activities that will advance science or technology not adequately provided by competitive and regulated markets.

In preparing this report, the Commission reviewed and reevaluated the mission statement above in light of the Legislature's authorizing language and directions for the PIER Program contained in AB 1890, SB 90, SB 1194 and AB 995. This review led us to conclude that the statement cited above continues to accurately and concisely reflect the Legislature's intended mission for the PIER Program, as well as the consensus recommendation of the CPUC and Commission Working Groups. Accordingly, the Commission will retain the above mission statement for the PIER Program.

1.4 Public Benefits Criteria and an Operational Definition of Public Interest Research

This section is in direct response to the AB 995 requirement that: "The initial investment plan shall include criteria that will be used to determine that a project provides public benefits to California that are not adequately provided by competitive and regulated markets."

In addition to public benefits criteria, this section responds to comments in the March 2000 report of the PIER Independent Review Panel that the Commission did not provide an operational definition of what constitutes public interest research, development, and demonstration. The term public interest RD&D is rooted in two State acts, AB 1890 and SB 90, which authorize and constrain the PIER Program. Note that the terms "public interest" and "public benefits" are not interchangeable. "Public interest" includes the provision of "public benefits" as described in this section.

Much discussion of these topics has occurred in the literature during the past several years and it has been concluded that no bright lines mark the boundaries between public interest research, development and demonstration and other activities such as commercialization and competitive or regulated research, development and demonstration. It is also not unusual for a

[3] See CPUC Working Group Report On Public Interest Energy Research, September 1996 and California Energy Commission Working Group Report On Public Interest Energy Research, March 1997.

project to have both public and private benefits. Projects have net societal benefits when the public value of benefits exceeds the public.

The Commission carefully considered the IRP's comments on this matter, and we agree that it is important to develop and apply across all program areas a succinct and related operational definition for determining what constitutes public interest RD&D activities. It is important to recognize, however, that the evolution of electric industry restructuring over the past five years in California resulted in the extensive analysis and discussion by legislative, administrative, and other forums of the complex topic of what constitutes public interest RD&D activities. Accordingly, to assist in developing an appropriate definition and operational criteria for public interest RD&D activities, we have reviewed a number of relevant materials.[4] These materials have proven extremely useful in developing the information below, and we encourage anyone who is interested in this topic to review these materials as well.

AB 1890 and SB 90 set forth the fundamental cornerstones of a succinct definition of public interest RD&D activities. They require that PIER fund "*only* (1) RD&D [efforts that] advance science or technology; (2) not adequately provided by competitive and regulated markets; (3) [that] provide in-state benefits … of value to California citizens; *and* (4) [that are in the energy-related subject areas of] environmental enhancements, end-use efficiency, environmentally-preferred advanced generation technologies, renewable technologies, and other strategic energy research…"[5]

Guidelines defining what is meant by RD&D can be found in the CPUC Working Group Report on Public Interest Research. The Report noted that:

> RD&D is the process of advancing science and technology from the initial stages of exploring a concept, through the laboratory and the application testing of components and systems, to the eventual introduction into the market.

The *CPUC Working Group Report* defined RD&D activities as:

> Research—the process to discover fundamentally new knowledge,
>
> Development—the application of new knowledge to develop a potential new technology or product,

---

[4] The materials reviewed include, but are not limited to, the following: (a) the Commission's Testimony/Report On Public Goods RD&D filed in the CPUC's Restructuring Proceeding (June 1995); (b) the CPUC's Restructuring Decision 95-12-063 (December 1995); (c) the CPUC Working Group Report On Public Interest RD&D (September 1996); (d) Assembly Bill 1890 as enacted into law (1996); (e) Senate Bill 90 as enacted into law (1997); (f) the Commission's RD&D Strategic Plan (June 1997); (g) the Commission's PIER1 and PIER2 General Solicitations (1998); (h) the Applied Decision Analysis Report on PIER Goals and Objectives (February 1998); (i) the Gas Research Institutes' Report on Criteria and Metrics For Public Goods RD&D (January 1999); (j) former CEC Commissioner David Rohy's Definition of Public Interest Research as provided to the IRP (August 1999); (k) the PIER Independent Review Panel Report (March 2000); (l) Carl Blumstein's Thoughts On What Constitutes Public Interest RD&D (April 2000); and (m) Commission Staff Discussion Notes On Public Interest RD&D (June 2000). These documents are available for viewing in the Commission's Dockets Office under Docket Number 01-PIER-1.

[5] Public Utilities Code Section 381 and Public Resources Code Sections 25620 and 25620.1.

Demonstration—the early application and integration of a new technology or product into an existing system.

In addition to the above succinct statutory definition of public interest activities within the PIER Program, the Legislature provided the following guidance and directives:

- PIER funded RD&D efforts must (a) address key technical and scientific barriers, (b) demonstrate a balance between short-term, mid term, and long-term potential, and (c) ensure that the funded activities do not unnecessarily duplicate efforts by other research organizations.[6]
- Benefits are achieved if the PIER Program provides citizens of the state with environmentally sound, safe, reliable and affordable energy services and products, in a manner, which demonstrates a balance of benefits to all sectors that contribute to the funding [of the PIER Program].[7]
- The Commission is given the discretion to determine which RD&D activities are not adequately provided for by competitive and regulated markets.[8]
- The Commission is expressly directed to utilize its adopted Strategic [RD&D] Plan … in the administration of [the PIER] program.[9]

With this basic legislative framework and guidance in mind, each required public interest element is further defined operationally below. But before setting forth the operational criteria for determining what meets the public interest requirements of the PIER Program, it is important to clearly recognize that *there are no bright lines* marking the boundaries between RD&D and commercialization activities. Nor are there clear boundaries between competitive, regulated and public sector activities, or between so-called public goods and private goods. In the real world, programs and proposals often contain elements that produce spillovers into one or more of the categories mentioned above.[10] As the 70 members of the CPUC Working Group on Public Interest Research unanimously agreed, attempts to draw clear and distinct boundaries among these categories in legislation or regulation inevitably leads to a sub-optimal allocation of resources. Boundary decisions are best made on a case-by-case basis by the appropriate

---

[6] Public Resources Code Section 25620.2 (a) (2-4).

[7] Public Resources Code Sections 25620 (a) and 25620.2 (a) (1).

[8] Public Resources Code Section 25620.1 (a).

[9] Public Resources Code Section 25620 (d).

[10] For example, it is not unusual for an RD&D project to have both public and private benefits. RD&D projects have net public benefits when the public value of benefits exceed the public costs of the RD&D. RD&D projects have net private benefits when the private value exceeds the private costs of the RD&D. The Commission challenge in PIER is to secure the most public benefit for Californians for the least public cost.

governing organization.[11] Similar conclusions have been reached by many other analysts and policymakers, including the Gas Research Institute (GRI) and the CPUC. [12]

The Commission has long recognized that it is both unrealistic and unwise to adopt rigid criteria that impose bright lines on the PIER public interest determination process. And in fact, the PIER planning and project selection process simply does not lend itself to the use of wholly objective metrics but requires the thoughtful exercise of professional judgment on each case. Nevertheless, we agree with the IRP's recommendation that a succinct public interest definition, informed by reasonable operational criteria, be applied consistently across all PIER Program areas. We think that it is useful to identify the basic definitional elements and key operational questions, which should be addressed before any informed public interest determination is made in the PIER Program.

Public interest operational criteria must be applied to a variety of important PIER Program activities. For convenience, we have grouped the various PIER Program activities into two major categories: (1) policy, planning, and evaluation and (2) project selection and management.[13] A brief discussion of these categories is needed to better understand how the public interest operational criteria apply to each category.

Policy activities establish high-level goals and provide fundamental direction for all PIER Program activities. Planning activities seek to identify those specific spending areas that are most likely to yield promising results consistent with relevant policies. The application of public interest operational criteria is particularly important in planning the PIER Program because key decisions made during this phase will directly affect the type of RD&D efforts that will be funded by the program. Periodic evaluation efforts to review the overall RD&D program will determine whether expected results have actually been achieved, and whether these results remain consistent with relevant public policies. We refer to the category of policy, planning, and evaluation as simply planning in the remainder of the text.

Project selection and management activities also require the application of public interest operational criteria. Project selection efforts require very careful application of public interest criteria because these activities actually create the project portfolios that ultimately will or will not result in public benefits for California. Project management activities must keep projects on track so that they remain in the public interest, but there is little specific application of public interest criteria for these activities. We refer to the category of selection and management as simply selection in the remainder of the text.

---

[11] See CPUC Working Group Report On Public Interest RD&D (September 1996), at page 2-2.

[12] GRI Publication Public Goods RD&D: Criteria and Metrics, at page 2 (GRI Publication #98/02, January 1999) and CPUC Restructuring Decision 95-12-063, 64 CPUC2nd at page 74 (December 1995).

[13] A third PIER activity category, technology transfer, seeks to ensure that results of RD&D are used and useful for California. However, we believe that proper application the public interest criteria to the categories of (a) policy, planning, and evaluation, and (b) project selection and management will lead to technology transfer activities that are in the public interest, so we will not discuss this third category further.

Based on the four public interest definitional cornerstones contained in AB 1890 and SB 90, the following basic public interest questions should be addressed, as well as the questions listed within each of these issues / categories. Criteria 2 and 3 below constitute the public benefits criteria mandated by AB 995. Note that the subsidiary criteria or questions listed under each of the four cornerstone criteria are applied where appropriate to RD&D planning or RD&D projects selection to provide consistency in the professional judgment that is applied.

1. Is the proposed project or activity research, development, or demonstration?
   - Does it create new knowledge, is it an application of new knowledge, or is it an application new to the market?
   - Does it advance science or technology?
   - Does it address any key technical or scientific barrier?
2. Is funding for the proposed project or activity not adequately provided by competitive and regulated markets?
   - Is there inadequate funding and why? [14]
   - Is there an unreasonable duplication of effort?
3. Will the project or activity produce benefits for California?
   - Will it contribute to the five public benefit energy objectives?
     - Improve energy cost / value
     - Improve the environment, public health, and safety
     - Improve reliability / quality / sufficiency
     - Strengthen the economy
     - Provide consumer choice
   - Will it contribute to a balance of benefits across market sectors and over time?
   - Do anticipated California benefits exceed costs?
   - Is the research adequately connected to the market?
4. Will the proposed project or activity address priority energy issues or problems?
   - Is the project consistent with the Investment Plan's priorities?

[14] Funding may be inadequate if it is being not provided at all or if the level is too low to achieve meaningful public benefits within a desired time frame. Reasons why funding may be inadequate include: (1) external cost concerns (the RD&D effort would address certain external cost concerns (e.g., global climate change impacts, etc.) that are not adequately accounted for by market pricing mechanisms); (2) non-excludable value concerns (the proposed RD&D efforts would provide potential benefits that cannot be sufficiently captured (i.e. excluded from competitors) by the private sector); (3) risk / reward concerns (the chance of achieving profitable success is too low or the pay-back time is too high for the private sector to undertake the proposed RD&D effort); (4) capital availability concerns (the financial costs of the RD&D effort are beyond the capability of private institutions to fund; and (5) basic information concerns (The RD&D effort seeks to acquire basic information that is both non-exclusive and non-rival in nature, and which Society needs in order to determine the impacts of existing or emerging conditions and technologies).

- Are the research strategies in the proposal consistent with the strategies identified in the investment plan?
- If the research strategies and activities in the proposal are not consistent with the Investment Plan, does the proposal provide a compelling case why the proposal strategy or activity is appropriate and will satisfy the other public interest criteria?

1.5 Other Important PIER Program Objectives

It is important to note that in addition to the substantive RD&D goals and objectives that the program seeks to achieve, there are a number of other important objectives for the program that are identified in the Commission's Strategic Plan. These additional PIER objectives, initially recommended in both the CPUC and Commission Working Group Reports discussed earlier, include the following:

- Creating a public interest RD&D knowledge base and disseminating information that will allow citizens, businesses, government, and other entities to make informed decisions concerning energy technologies and services.
- Ensuring that the public interest RD&D program is connected to the market by (a) collaborating with market and public interest stakeholders to determine research and market needs during program planning, (b) incorporating the assessment and understanding of market needs and technology status into appropriate phases of RD&D projects, and / or (c) transferring public interest RD&D results into the marketplace through partnerships and other actions. [15]
- Ensuring public input and accountability for the public interest RD&D program by (a) conducting an open and flexible planning and decision-making process that involves stakeholders in both planning and implementing the program, (b) using advisory committees and expert panels to guide programs and evaluate project proposals, and (c) using an independent group for periodic overall program review and evaluation.
- Ensuring the efficient administration and stewardship of public interest RD&D funds by (a) implementing a streamlined project acquisition and funding process, (b) using prescribed project evaluation criteria to select projects based on merit, (c) leveraging limited public interest RD&D funds through public / private partnerships to the extent possible, (d) managing projects flexibly and effectively, and (e) avoiding excessive overhead costs.
- Providing leadership and coherence for California's public interest RD&D efforts by (a) coordinating with public and private RD&D entities, and (b) integrating this effort with the Energy Efficiency / Renewables programs and other public interest energy efforts.

---

[15] For example, the PIER Program can increase the probability of success of PIER funded technologies, and can accelerate the penetration of new products into the market, by supporting companies who intend to enter RD&D incubators, where technical entrepreneurs and innovative companies gain support in developing startup capacity and in attracting partners and investors.

Chapter 2 — The California Energy Context for the PIER Program

2.1 What is the California Energy Context?

California is currently experiencing a great deal of turmoil, concern, and uncertainty regarding its recently deregulated electricity market, and decisions about how to spend research funds cannot be made without giving careful consideration to these events. However, research projects funded today may take years to come to completion and then years more to make an impact on the market.

Because of this lag time between funding a project and seeing those public funding dollars make a significant contribution to society, research managers need to have an understanding of what is currently happening in their subject areas and a working picture of what the future might be like. The Commission developed this picture, or set of assumptions, about California's future for the purpose of planning a five-year energy research investment plan, and called it the California energy context. The California energy context provides details about the present demographic, economic, technological, social, political, and environmental situation in the state, and what California's energy future may look like over the next decade under certain conditions. The Commission has used the California context as the basis for the development of the PIER *Five-Year Investment Plan, 2002 Through 2006.* [16]

2.2 Important Drivers and Trends Affecting California's Future

California's energy future will be determined by a number of factors:

- Demographic and behavioral patterns
- Advances in Technology
- Economic Conditions
- Social Values, Public Health and Safety Concerns
- Political/Institutional Uncertainty
- Climate and the Environment.

---

[16] The California energy context was developed using a variety of sources, including: California Energy Demand, 2000-2010, California Energy Commission Staff Report P200-00-002, June 2000; California Energy Commission, Trends and Issues in California's Future, (Staff Workshop, June 29, 2000); California Energy Commission, High Temperatures and Electricity Demand: An Assessment of Supply Adequacy in California, (Staff Report, July1999); California Energy Commission, Electricity Generation Emissions (Report to the Legislature, July 1999); California Energy Commission and Electric Power Research Institute (EPRI), Environmental Impacts of New Generation in California (Workshop, October 29, 1999); EPRI, Electricity Technology Roadmap (1999); PIER Independent Review Panel, Preliminary Report To Legislature (March 2000); California Air Resources Board (Iannucci, Eyer and Hogan consultants), Air Quality Impacts Associated with Economic Market Potential for Distributed Generation in California (March 2000); University of California Energy Institute (Severin Borenstein and James Bushnell), Electricity Restructuring: Deregulation or Reregulation? (February 2000); Bill Joy, The Dark Side of Technology, (Commonwealth Club of California Newsletter, June 6, 2000).

These factors tend to drive both the demand for energy and the supply mix that will meet that demand. These factors also determine the delicate equation of meeting the economic and personal need for energy and preserving the natural environment in the state. For these reasons, many people have chosen to call these factors drivers.

In this section we discuss each of these drivers. We document where possible, and otherwise use judgment to describe the present situation, the trends we see in each area, the impacts that these trends are likely to have on California's energy system, and the specific energy problems or concerns that these trends and impacts may produce. These problems form the basis for the integrated PIER analysis contained in Chapter 3, which describes the strategies behind PIER-funded RD&D, work designed to solve the problems. **Table 1** contains a summary of key drivers and trends.

Table 1. Important Energy-Related Drivers and Trends

Demographics	Advances in Technology	Economic Conditions	Social Values	Political Factors	Climate and Environment
Significant statewide population growth Highest population growth in hot inland valleys Increasing demand for new, larger homes with central air conditioning and more appliances Increased telecommuting means more people at home during the day Population growth in surrounding states	Increased automation of homes, commercial businesses, and industry Increased use of advanced combustion turbines, and control technologies Increased use of distributed generation and renewable resources Increased efficiency and other demand side management Many new high-tech industries demand large quantities of electricity and require higher quality, more reliable power	Growth of industrial and commercial sectors Further move towards e-commerce and service economy Modernization of aging plant and equipment Increased decommissioning of aging hydro-electric facilities Continued use of aging fossil generating capacity Uncertainty related to energy resource availability and costs	Cutting edge state for environmental concerns Greater demand for green energy and other technologies Consideration of environmental justice becomes California law NIMBY regarding distributed generation, transmission lines, and large power generation facilities Increased demand for recycling	Uncertainty about energy deregulation and possible reregulation Uncertainty about global climate change (Kyoto) initiatives Difficulty siting distributed generation and other energy facilities because of local regulations Increasing scarcity of emission offsets & NOx allowances More stringent wastewater discharge standards (e.g. dairy industry required to treat animal wastes.) Increasing land use restrictions	Increased demand for water, more scarcity, deeper wells Greater emissions More pressure on land use, habitats and views Climate change impacts in California are unknown (could be more or less rain/snow)

2.2.1 Demographic and Behavior Patterns

California's population is expected to grow by 7.8 percent between 2000 and 2005, by an additional 6.9 percent between 2005 and 2010, and by an additional 13.7 percent between 2010 and 2020. Overall, California's population is expected to increase by 31.2 percent over the next 20 years.[17] This is a very high growth rate for a state whose population is already at around 34.6 million people. Much of this increase in growth will be fed by immigration, roughly 250,000 legal immigrants per year if past patterns hold true.

Where will all this growth be taking place? All of California's 58 counties, with the exception of San Francisco County, are expected to experience an increase in population. However, the fastest growing counties in California on a percentage basis over the next ten years are projected to be those counties in California's hot inland valleys. For example, the fertile Central Valley south and east of San Jose, which provides half the nation's fruits and vegetables, is ranked as the most threatened farm region in the country, according to American Farmland Trust, a national non-profit group. Some 500,000 acres have been lost to development in the past 20 years with as much as 3.5 million more acres at risk in the next 20 years.

Population increases in these inland areas mean more residential housing, with the trend towards bigger houses, many with second stories, and few if any with mature, shade-producing landscaping. More suburban housing tracts mean more commercial shopping malls and services, warehouses, office complexes, schools, roads and other infrastructure, and increased congestion on freeways as workers commute to larger metropolitan job markets. This suburbanization of California is expected to bring about increased air conditioning usage not only from new residential housing units and surrounding new businesses, but also from the hot summer climate of the areas where most of the new houses will be built.

2.2.2 Advances in Technology

By 2006, the U.S. Department of Commerce forecasts that almost half of the U.S. workforce will be employed by industries that are either major producers or intensive users of information technology products and services. Even today, information technology industries have contributed more than one-third of the nation's real economic growth. In the past five years, semiconductor manufacturing has grown to become the nation's largest manufacturing industry.

In addition, between 1997 and 1999, worldwide Internet use increased 55 percent. The number of Internet servers increased 128 percent, while the number of new Internet address registrations rose by 137 percent.[18] Intel estimates that a billion Internet connections will be made over the next five years. And the data center market, which provides Internet data server hosting services in the business-to-business marketplace, estimated to represent a market of $35 to $50 billion today, is expected to reach $70 to $100 billion by 2005.

---

[17] State of California, Department of Finance, County Population Projections With Race/Ethnic Detail. Sacramento, California, December 1998.

[18] Bank of America, The Power of Growth: Energy Technology Industry Overview, (June 2000).

The high tech industry, a major component of California's vibrant economy, places enormous new demands on the electricity system in terms of power quantity, quality, and reliability. In Santa Clara, the heart of the Silicon Valley, peak demand climbed by 33 percent during the past five years.[19] No longer is it only hospitals and military installations that demand absolute reliability; Internet data centers and silicon chip manufacturers require 99.9999 percent reliability,[20] higher than the system can currently provide. The automation of building systems and industrial processes has led to increased requirements for improved power quality. The Internet economy is changing building type needs, from retail to distribution warehouses, where companies like Amazon.com conduct their electronic transactions.

With the spread of personal computers and the Internet we are also witnessing an increase in telecommuting. Increasing numbers of people are running businesses out of their homes, many of which would not otherwise be occupied during weekdays. This technological innovation contributed, and will continue to contribute, to California's strong economy in the years ahead, but may also require more electricity for air conditioning.

2.2.3 Economic Conditions

The third major driver that will shape California's energy future is economic. California's economy is usually cyclical. There are probably an equal number of economists predicting a continued robust economy as there are those who predict a downturn. However, given the worldwide increase in e-business and California's pivotal role in this area, plus the national importance of California's agricultural, electronics, and entertainment industries, we believe that the overall trend is for California's economy to remain strong. [21]

However, the current uncertainty about electricity deregulation, mounting power company financial losses, electricity shortages, the threat of rolling blackouts, and the prospect of sharply higher energy prices and price volatility for residential and business customers could slow California's booming economy of the past several years.

There are several related trends associated with this prediction of a continued strong economy. A research brief by the Public Policy Institute of California (February 1999) shows that income inequality in California widened significantly in recent years. The research brief states that the income inequality has risen sharply in the state over the past two decades and that it has grown faster in California than in the nation as a whole. The growing gap between the rich and the

---

[19] Silicon Valley Scrambling for Protection from Blackouts, http://www.latimes.com, Jan. 8, 2001.

[20] Bank of America, The Power of Growth: Energy Technology Industry Overview, (June 2000).

[21] John B. Taylor, a professor at Stanford University and a research associate at the National Bureau of Economic Research, has stated that the current economic boom will continue in the future because of three factors that are new about the current economic climate: 1) there are less frequent down turns or recessions than in past, partly because of good monetary policy which has kept inflation in check; 2) productivity growth, the amount each worker can produce in the same amount of time with the same amount of effort, is higher than ever, with the last four years showing productivity growth that is faster than it was in the previous 20 years; and 3) the new unemployment rate is lower than it has been in 30 years. (John Taylor's Remarks at Conference On Structural Change and Monetary Policy, March 3-4, 2000).

poor in California results not only from the rising income among the well off, but also from the substantial decline in real income among those in the mid to lowest levels of the income distribution. The Public Policy Institute states that because the trend has persisted and has been relatively unresponsive to economic upturns, it appears unlikely that the situation will correct itself through economic growth.

2.2.4 Social Values, Public Health and Safety Concerns

Californians strongly value a clean, healthy, and safe environment and are particularly concerned about air and water pollution in their communities.

While in many areas of California air quality is improving, five of the six metropolitan statistical areas in the Nation with the worst air quality are all in California—Riverside-San Bernardino, Los Angeles-Long Beach, Bakersfield, Fresno, and the Ventura metropolitan statistical area.[22]

Because so much of the state does not meet ambient air quality standards (the official definition of clean air), Californians can be expected to remain very concerned about environmental public health issues in the foreseeable future. Not only are Californians concerned about outdoor air quality, but there is also a growing concern with indoor air quality. People are aware that buildings can make people sick.

Clean drinking water is another area of strong social concern to Californians. Industrial and utility wastes in California's drinking water have been well documented.[23] This, along with impacts on fish and wildlife, and competition for limited water resources, make it increasingly difficult to find water for power plant cooling. These social concerns about pollution are expected to continue and perhaps increase in the years ahead.

2.2.5 Political/Institutional Uncertainty

Public policies and political decisions are constantly undergoing change in California. For example, the electricity industry has been in the midst of a transition from tightly controlled regulation to a more free market type of operation. Regulatory reforms have also radically changed the way natural gas markets function.

With the passage of AB 1890 in 1996, California's century-old electric utility regulatory system was fundamentally altered.[24] The legislation promised to bring about a more competitive electric generation market structure, one that would provide lower costs, more reliable electric

---

[22] U.S. Environmental Protection Agency, Office of Air Quality and Standards, 1988-97.

[23] Industrial and Utility Ground Water Pollution, California Pollution Data Base.

[24] The legislation set up new institutions. A Power Exchange (PX) was created and charged with providing an efficient and competitive auction to meet the electricity loads of the exchange's customers. An Independent System Operator (ISO) was given centralized control of the statewide transmission grid and charged with ensuring the efficient use and reliable operation of the transmission system. AB 1890 also directed the ISO to be able to secure generation and transmission resources needed to achieve specified planning and operational reserve criteria. Finally, a five member Electricity Oversight Board (EOB), was created to oversee the PX and the ISO, and appoint governing boards broadly representative of California electricity users and providers.

service, and economic benefits, among other things, while at the same time preserving California's commitment to developing diverse, environmentally sensitive electricity resources.

However, after approximately three years of a transitional period before full deregulation, increasing electricity demand caught up with supply. This, combined with natural gas fuel shortages and a flawed market structure, resulted in escalating energy costs for utilities, which could not pass on their increased costs to customers. When the transition period ended in San Diego, electricity bills doubled and tripled. Consumers rebelled and refused to pay.[25] This has left government officials in California and Washington, D.C., struggling to find a compromise between the demands of California's two largest utilities for higher rate increases to cover multi-billion dollar deficits, and voters angry at being lead down an apparently risky path in hopes of lower electricity prices through deregulation. In this uncertain environment, companies have withdrawn applications for six new peaker generators, although base load plants have remained in the permitting pipeline.

2.2.6 Climate and other Environmental Conditions

The last major driver influencing California's energy future is climate and other environmental conditions. This driver, like the last one, brings more uncertainty than anything else. California's climate is typically marked by variable cycles and extremes, for example, periods of prolonged drought are sometimes followed by periods of abundant rain, and extremely hot summer days are often followed by much cooler ones, etc. One unanswered question is whether the variable climate patterns in California are likely to change significantly in the years ahead.

Increasing numbers of researchers studying global warming believe that mean global temperatures are getting higher.[26] What this means for California, however, is not clear. While over the last decade a number of assessments have been done on the potential impact of climate change in California, the findings vary from study to study. However, most scientist do agree that we will see an increase in temperatures. Climate projections suggest that temperatures in California might increase by 3-4 degrees Celsius by 2030, and by 8-11 degrees Celsius by 2090.[27] The climate scenarios also suggest a more vigorous hydrologic cycle resulting in both more and heavier rain and more evaporation.

While California's existing climate is inherently variable, and California experienced major climate extremes in the past (such as extended droughts), the frequency and extent of change may increase in the future. The concern now is that climate change may proceed more quickly and more erratically. Unfortunately, no one can predict with certainty future climate impacts on the state. In fact, some areas of California may get cooler while others get warmer.[28] Some areas may have more droughts and other areas more floods.

---

[25] Governor Takes Action Against Utility Bills, San Diego Union, July 24, 2000.

[26] Climate Change 2001: The Scientific Basis, Intergovernmental Panel on Climate Change (IPCC), Shanghai, Jan. 20, 2001.

[27] Climate Change and Our Nation, President's Council of Advisors on Science and Technology, 1999.

[28] Ibid.

Climate is not the only uncertain environmental factor Californians face in the future. The size and number of wild fires will be affected by a variety of unpredictable factors, including forest management practices, climatic conditions, and human behavior.[29] California's widely variable level of seismic activity is another environmental uncertainty that could profoundly affect its energy situation in the future.

2.3 Potential Energy Impacts From California Drivers and Trends

All of the drivers and trends discussed above are likely to result in a number of important energy impacts in California in the years ahead. **Table 2** summarizes the major examples of these energy impacts and related issues of concern.

For purposes of discussion, we have decided to group these potential energy impacts under three separate headings, namely demand, supply and other impacts.[30]

---

[29] Wild fires can damage transmission and distribution systems, as well as hydroelectric and other generation facilities.

[30] While it is tempting, and perhaps possible, to map each of these potential energy impacts into the six major drivers and trends discussed earlier in this report, most of these impacts are expected to result from a combination of various drivers and trends, and a rigorous causal mapping effort would not likely yield a more useful understanding of California's energy future.

Table 2. Energy Impacts and Consequences of Not Addressing Problems

Energy-Related Impacts Resulting From Drivers and Trends		
Increased residential energy use Higher peak loads from air conditioners Increased energy use by commercial and industrial sectors, particularly the high tech sector Demand for higher quality, more reliable power Reliance on a single fuel, natural gas, with threatened shortages Possible rolling blackouts Less electricity available from surrounding states Increased power plant operating costs Environmental requirements Greater use of aging facilities	Siting difficulties for new energy facilities Emissions limitations NIMBY attitudes Environmental justice regulations Land use restrictions Water more scarce and costly Wet cooling discouraged Greater electricity use for pumping and treating more water Emissions constraints NOx allowances more scarce Possible global CO_2 agreements Inefficient operation of buildings because of changing use Strained generating capacity and transmission and delivery systems	Lower efficiency and higher emissions from generation as older facilities are run longer to meet demand More outages Higher emissions from increased new generation and backup generation Increasing marginal costs of electricity Reduced interest in energy efficient design if electricity prices decline Greater use of electricity for pollution controls Political pressure to reregulate or reduce electric rates makes construction of new power plants unattractive
Energy-Related Problems for California		
Possible fuel supply shortages Less reliable electricity supply Higher emissions control costs	Higher energy costs and price volatility for businesses and residential consumers Higher emissions, pressure on land use and increased use of water	Greater threats to health and safety Strains on the economy from reduced productivity and higher energy costs

2.3.1 Energy Demand Impacts

In the subsections below, we describe the major energy demand impacts that are expected to occur from current drivers and trends.[31]

(a) Energy Demand Will Continue to Grow, Often On-Peak

California demographics indicate that there will be an increasing demand for electricity, often on peak, in the years ahead. More people, many of whom will be living and working in warmer inland climates, will demand more electricity to power their homes and businesses, and much of this demand, particularly from air conditioning loads, is likely to occur during the peak consumption periods, between noon and 6:00 p.m., on very hot days. Also, rising population means increasing demand for water, which requires large quantities of electricity for pumping and treatment before and after use.

(b) End-Use Energy Efficiency Will Need Ongoing Improvement

Projections show that energy will continue to be wasted at the point of use. Multiple factors contribute to this, including inefficient or unavailable equipment and technologies, inefficient design and construction practices, and faulty or inefficient operation of building systems.

Thus, for example, current Commission projections show that if existing energy efficiency efforts (such as those currently overseen by the Public Utility Commission under the Public Goods Charge Account) only continue at the current levels for the next five years, approximately 12,000 GWh of potential reduced demand through energy efficiency will remained untapped annually.

(c) Energy Demand Will Grow in the Agricultural Sector

While the residential and the commercial sectors of the economy use the most energy on a per sector basis, the demand from California's agricultural sector will grow as energy intensive processes are used to compensate for farmland taken out of production. Currently demand growth in the agricultural sector is flat, but is expected to be roughly 2.7 percent annually later in the decade.[32] This compares with annual growth of 1.7 percent for the residential sector and 2.0 percent for the commercial sector.

(d) Energy Demand Will Continue to Grow in the Manufacturing Sector

Though the majority of the jobs in California are shifting to the service industry, and the manufacturing sector is becoming a smaller part of California's economy, the manufacturing sector will continue to contribute the greatest share to California's Gross State Product (GSP).[33]

---

[31] Though there has been some attempt to quantify the specific energy demand impacts of specific drivers and trends, the effort needed to quantify these impacts would divert attention from the real concern here: What energy demand impacts are likely to result from the drivers and trends, and how will these help determine how best to invest PIER Program funds?

[32] Ibid.

[33] Ibid.

Commission projections show that the manufacturing sector will experience a demand growth of 2.2 percent annually from 1998 to 2010. In addition, three of the top six fastest growing industries in the state—chemicals products, electronic components, and transportation equipment—are also among the top four industries in terms of energy consumption. These industries have projected 12-year energy demand growth rates of 30 percent, 36 percent, and 47 percent, respectively. In addition to high growth rates, some manufacturing sectors, such as electronic components, require high quality power and exceptional reliability.

(e) Demand for Non-Energy Benefits Related to Energy Systems Will Increase

In the residential sector, consumers are placing comfort as a priority criteria when making choices related to energy systems. Focus group studies show that individuals rank comfort and saving money as the two most important benefits of energy efficiency.[34] In the commercial and industrial sectors, productivity (measured in terms of worker output, retail sales volume, and student performance) emerged as a priority when making choices related to energy systems.

In both the residential and commercial sectors, concerns regarding indoor environmental quality and other health issues are critical to building occupants and impact energy use decisions.

(f) California's Ongoing Economic Growth Will Affect Energy Demand

California's strong economy is likely to affect energy demand in a variety of ways. For example, people at the upper end of the income spectrum will tend to have bigger homes, more new appliances and discretionary end-uses (e.g., home video projection systems), and less concern for the amount of energy consumed because energy bills are a much smaller faction of disposable income. However, many people in higher income brackets are also concerned about the environment and may tend to demand, and be able to pay for, green energy-efficient options.

At the other end of the economic spectrum, lower income people may not be able to reduce their energy demand through the purchase energy-efficient homes and appliances, even though energy costs often consume a very high percentage (sometimes as high as 17 percent) of their income.

Continued California prosperity may result in reduced attention to lowering operating costs and maximizing occupant comfort during the design and construction of buildings. If buildings are being designed and constructed at record paces to keep up with demand, it is possible that little time and spending will be devoted to incorporating above-standard energy efficient products or in meeting occupants needs effectively. This lack of concern with energy design choices in residential and non-residential buildings creates what energy policy makers call a lost opportunity, a foregone chance to improve the efficiency of a structure that will be using energy for 30 to 40 years or more.

---

[34] Bevilacqua-Knight Inc., Focus Groups To Investigate Public Attitudes To Energy Efficiency, (Consulting Report to the California Energy Commission, December 20, 1998).

2.3.2 Energy Supply Impacts

The energy supply picture in California is clouded by many factors, perhaps the most important of which are potential fuel shortages, institutional uncertainties, and the public's concern for a safe and clean environment.

(a) More Natural Gas Fired Generators Will Be Licensed in California

From siting cases recently received at the Commission, it is clear that natural gas-fired generators will be the predominant new generating technology in California for the foreseeable future. New natural gas-fired combined cycle power plants—which generate first with combustion turbines and then with steam turbines—now have fuel efficiencies approaching 60 percent, compared with 1950s era steam generators that operate at efficiencies of between 30 percent and 40 percent, making these new plants more economical to operate.

(b) Increased Demand for Natural Gas for Electricity Generation May Result in Shortages

Natural gas is currently the only environmentally acceptable fuel for major new electricity generation in California. This leaves the state vulnerable to natural gas supply shortages, gas price volatility, and pipeline capacity limitations.

(c) The Availability of Electricity Generated in Neighboring States Will Decrease

California has historically received a significant share of its electricity from neighboring states, i.e., electricity generated from hydroelectric dams in the Northwest, or coal and nuclear plants in Arizona, Nevada, and elsewhere. However, Census Bureau figures show that in the last ten years, Washington, Oregon, Arizona, and Nevada have been rapidly growing in population. According to Census figures, from 1990 to 1995, Oregon's population grew by 10 percent, Utah's by 16 percent, Arizona's by 18 percent, and Nevada's by 27 percent.[35] Generating units located in these rapidly growing states are increasingly called upon to provide service to their expanding local populations, and California can expect to find such supplies decreasing and more expensive in the years ahead.

(d) Aging Fossil-Fired Generating Plants Will Require Modernization or Retirement

While California's fossil-fired generating plants may not be old compared to facilities in some East Coast states, a significant number of California's fossil-fueled plants are clearly aging. Over the past six years, existing generation capacity has declined by four to five percent as old facilities were taken out of service.[36] Over next 10 to 20 years, most older plants will require increased maintenance. They will probably experience more forced outages and become candidates for replacement by more modern generating technologies.

---

[35] Population Estimates Program, Population Division, U.S. Census Bureau, Washington, DC 20233, http://www.census.gov/population/www/estimates/statepop.html.

[36] See the following California Energy Commission documents: 1994 Electricity Report, 1996 Electricity Report.

(e) Existing Nuclear Power Plants Are Aging

Negative sentiment towards nuclear energy, whether warranted or not, is wide spread throughout California, and the state has prohibited the construction of any new nuclear power plants until a way to permanently dispose of the nuclear waste has been found. In June 1989, the residents of Sacramento County voted to close the Rancho Seco Nuclear Generating Station, which had operated since 1975. While Rancho Seco was capable of producing about half of Sacramento County's power needs, customers of the Sacramento Municipal Utility District voted to shut the plant down, in part, because of increased rates, concerns about public health and safety, extended maintenance periods, and the unreliability of the plant. Currently, there are nuclear power plants operating in the state, including Diablo Canyon with a capacity of 2,160 MW, and San Onofre with a capacity of 2,340 MW.

(f) Distributed Generation Will Increase Significantly in California

Most experts agree that the amount of distributed generation (DG)—smaller power plants located closer to loads—will increase significantly in the future. According to the Commission's Power Plant database, as of April 1999, there were more than 650 power plants in California sized between 100 kW and 20 MW. These units totaled 3,203 MW, or about 6 percent of California's system peak for 1999. Between 2001 and 2003, another 500-1,000 MW of cost-effective DG could be added to the system, depending on resolution of barriers, the role of utility distribution companies, and further restructuring to allow distribution competition.

At a recent national distribution generation conference, experts predicted that DG would develop slowly at first in California, but begin to gain speed by 2001. These experts foresee many niche applications before 2005, with an increasing market between 2005 and 2008. Many local DG companies predict that within 10 years, 10 percent of all energy in California will come from DG, and a decade thereafter the figure could reach 30 percent.[37]

2.3.3 Other Energy-Related Impacts

There are a number of energy-related impacts that cut across both the demand and the supply sectors. Important energy-related impacts that seem to be on the horizon at this time include the following:

(a) Emission Credits Are Becoming Scarce

Emission credits are a kind of limited currency that can be exchanged between polluting industries to allow a new industry to locate in an area with poor air quality. For example, these credits can be used to help offset the adverse effects on air quality of building additional generation capacity in a highly polluted area. But throughout California, stationary source emissions credits are being used up. In Southern California in particular, available credits have declined dramatically since 1993.[38] This means it will become harder in the future for new

---

[37] Joe Iannucci, Distributed Utility Associates, Comments at California Energy Commission, Trends and Issues in California's Future, (Staff Workshop, June 29, 2000).

[38] In 1993, emission credits for NOx totaled 14,000 lbs / day. In 2000, the figure is closer to 1,100 lbs / day. CO credits have gone from 7,000 lbs / day in 1998 to 4,700 lbs / day today. And PM10 credits have been cut

generating facilities to locate near California's large metropolitan areas where the power is most needed.

(b) Public Involvement in Siting New Power Plants Remains High

If there is one common message at Commission workshops concerning the siting of new power plants, it is that the public is increasingly demanding vigorous participation in the process. Not only is there resistance to having a power plant in my backyard (NIMBY), there are also new Federal and California laws requiring environmental justice[39] in siting new power plants. Growing public involvement may affect where and how future power plants are sited in California in turn impacting the availability and cost of supply.

(c) Climate and Other Environmental Impacts Will Remain Uncertain

The predominant climate in California is one of hot dry summers and cool wet winters. This results in an annual electricity cycle of high peak loads in the summer, particularly on long hot days. The possibility of global warming raises the issue of even greater climatic fluctuations, such as heat spells and fires, floods, and extended droughts.

Changes in hydrological cycles may reduce water availability for hydroelectric plants and may cause an increase in electricity demand as pumps are pressed into action to extract ever declining levels of groundwater. The response to natural or technological impacts on the electricity infrastructure is also important. For example, wild fires may damage transmission lines and also affect watersheds and the amount of water available for power generation. Also, the Loma Prieta earthquake of 1989 caused major disruptions in gas and electricity services to San Francisco.

(d) The California Electricity Crisis of 2000-2001: Reliability at Any Cost

By January 2001, California's restructured electricity system devolved under supply and demand pressures into a game of keeping the electrons flowing at almost any cost. Since Spring 2000, there have been jarring price spikes, price caps, reduced electricity imports from other states, rolling blackouts in the San Francisco area, extraordinary natural gas price increases, and concentrated power plant outages. As the crisis grows, the operators and regulators are resorting to increasingly extreme measures.

Starting in May 2000 and ending late in December, the California Independent System Operator (ISO) called a total of 55 Stage 1, 36 Stage 2, and one Stage 3 Emergencies. By declaring such emergencies, the ISO could authorize utilities to interrupt service to their interruptible rate customers, stop state Water Projects pumps (in the case of a Stage 3 Emergency Notice), order in-state generators that had signed Participating Generator Agreements with the ISO to increase output to maximum, and make special purchases out-of-state at rates higher than the price caps levied on in-state generators.

---

nearly in half from 1999 to 2000, going from 2,200 lbs / day to 1,200 lbs / day. This trend seems unlikely to decrease.

[39] *See, e.g.*, Presidential Executive Order 12898 (February 11, 1994); California Government Code Section 65040.12 and Public Resources Code Sections 72000 *et seq.*

Even these measures have not been enough. In-state power plants that had been run continually during the summer and early fall could no longer avoid outages to catch up on previously planned maintenance. Power plants in the South Coast Air Quality Management District that were subject to the RECLAIM NOx emission credit program could not afford to buy more credits so they shut down. Hydroelectric generation from the northwest dried up. And as the price of electricity escalated, out-of-state generators became concerned about their exposure to the risk that they would not be paid for the power they supplied to California. On December 14, 2000, the U.S. Secretary of Energy, Bill Richardson, invoked a seldom-used emergency authority under terms of the Federal Power Act. He ordered all power producers and marketers who supplied power to California in the 30 days prior to the order to deliver any uncommitted power when the California ISO declared its electricity supply inadequate. The order has been extended four times and is now set to expire in 2001.

It would be an understatement to say that California's electricity crisis of 2000-2001 is currently unresolved. It will have major impacts—as yet unknown—on the people of California and the economy of the state.

2.4 Problems Regarding California's Energy Future

As reflected at the bottom of Table 2, there are currently a number of energy-related problems in California. These include concerns about (1) the cost and affordability of electricity, (2) the reliability and quality of electricity, (3) electricity-related health and safety problems, and (4) electricity-related adverse impacts on the natural environment. These are discussed below.

2.4.1 Problems Regarding Demand

For all the reasons discussed above, electricity demand is increasing. This increase in electricity use has a potential impact on energy availability, energy cost, and the environment. In addition, peak demand for electricity is rising faster than demand in non-peak periods. This results in an electricity system that is less stable during peak periods and seasons. These concerns could well result in higher energy costs for businesses and consumers, and strains on the local economy from reduced productivity.

Along with this disproportionate increase in peak demand and an overall increase in demand for energy, end-users of electricity—customers—are requiring and demanding higher quality, more reliable power. As mentioned above, many industrial users require 99.9999 percent reliability.

2.4.2 Problems Regarding Supply

New generating supplies are not increasing fast enough to meet demand. There has been a decline in existing California generating capacity, which could extend well into the future. As the state has experienced this winter, Stage 3 Emergencies have resulted in rolling blackouts and lost service to hundreds of thousands of customers.

While distributed generation and renewables offer the possibility of additional generation, there are many barriers to their deployment. For example, utility workers and end users need communication and disconnect controls to protect them from distributed power sources going on-line unexpectedly. With increased use of natural gas for generation of electricity, California is experiencing high prices and is vulnerable to fuel supply interruptions. Furthermore, with all the demand for increased electricity supplies, the cumulative environmental effects caused by electricity generation, transmission, and distribution are not adequately understood.

2.4.3 Problems Regarding Transmission/Distribution

Transmission systems throughout the state are approaching maximum capacity during peak demand periods, threatening reliability. Part of the reason for this is that the state's transmission system has not been expanded or upgraded in many years, resulting in congestion in the lines. In addition, the existing transmission system is not operating at the capacity that new technology would allow.

2.4.4 Other Energy-Related Problems

California's energy future is likely to present increasing problems regarding the environment. For example, the increased use of fossil fuels for electricity generation will increase emissions of greenhouse gases. Widespread use of certain forms of distributed generation could have negative effects on air quality (NO_x, CO, PM10). Emission control costs may rise, as will the cost and scarcity of NO_x trading credits. Currently, there are inadequate methods and tools for predicting, measuring, and mitigating the environmental impacts of electricity generation, transmission, and distribution. Finally, California's electricity system is susceptible to seismic and fire damage, which could further strain reliability and increase the cost of electricity.

The deregulated electricity market is not operating as anticipated. Electricity prices, when price controls were recently lifted in San Diego, shot up, not down as was expected when deregulation was put in place. California's two largest utilities, Southern California Edison Company and Pacific Gas & Electric Company, have amassed billions of dollars of unreimbursed expenses by purchasing power at wholesale rates several times higher than regulated retail rates for customers. The exponential expansion of market transactions among generators of electricity, transmission operators, the ISO, and customers has strained system reliability. Electricity restructuring has caused many types and sources of data to be deemed proprietary and removed from the public domain, making planning for energy use and development more difficult. In addition, the California Power Exchange (CalPX) and ISO do not consider the environmental impacts of available energy sources, other than NO_x, when they dispatch power. Other unforeseen consequences of deregulation may occur in the future.

As can be discerned from the cumulative effects of the drivers and trends described above, higher electricity prices and possibly price volatility may persist in the PIER planning horizon.

2.5 Summary Regarding the California Energy Context

The California Energy Context has presented various drivers, trends and energy impacts that are likely to significantly influence California's energy future. As previously highlighted, these drivers, trends and energy impacts give rise to many serious concerns about a wide variety of issues which California needs to address if it is to have a reliable, affordable, safe, healthy, and environmentally sound electricity system. In the next chapter of this report, we group California's energy concerns into four major problems and describe strategies, amenable to RD&D, for the PIER Program to address these problems and find solutions.

Chapter 3 — PIER's Strategies

3.1 An Overview of the PIER Integrated Planning Methodology

As indicated earlier in this report, the PIER Program seeks to maximize the public benefits that California electric ratepayers and citizens receive from their ongoing investments in PIER-funded RD&D activities. To achieve this goal the PIER Program must develop and implement a planning methodology that identifies, evaluates, and selects those RD&D strategies that are most likely to ensure that PIER funds are allocated in an integrated and cost-effective manner. This integrated planning methodology consists of the following steps:

Step 1 Identify the energy problems of highest concern to California.

Step 2 Determine whether existing and planned RD&D activities are adequately addressing these important energy problems.

Step 3 Select a portfolio of strategies, amenable to RD&D activities and integrated across the PIER subject areas, to address the major energy problems in the state.

3.2 Step 1: Identify the Energy Problems of Highest Concern to California

Chapter 2 identified many energy problems of concern in California's future. These problems have been aggregated into four broad topics that are of highest concern to California at this time:[40]

1. Electricity demand is increasing faster than supply, resulting in high prices and possible service interruptions.
2. Rapid growth in peak electricity demand threatens the reliability of the electric system.
3. Electricity and environmental concerns need to be balanced (e.g., environmental constraints may affect electricity supplies, while new applications of electricity may offer possibilities for environmental improvement).
4. Significant market uncertainty and price volatility are occurring because of the current market structure, fuel shortages, emission allowances and high peak demand.

Table 3 summarizes these four major energy problems that provide the framework for reviewing current RD&D activities and selecting the RD&D strategies that PIER will implement in the future. We will discuss each of these major problems in further detail in Section 3.4 below.

---

[40] These four energy problems of highest concern to California were derived from approximately 81 specific problems identified by the PIER Team Leads after reviewing the California Energy Context. These 81 problems were grouped into primary and subsidiary subsets, and then aggregated into the four major problems listed above.

Table 3. Electricity Problems of Highest Concern in California

Problem 1 – Electricity Demand Is Increasing Faster Than Supply	
There are barriers to the deployment of new central generation. There are barriers to the deployment of new distributed and renewable generation There has been a decline in existing California generating capacity, which could extend into the future.	Electricity use is increasing with potential adverse impact on energy availability and cost. An increasing number of end users are requiring higher quality, more reliable power. There are missed opportunities for efficiency in buildings, industry, agriculture, and water management.
Problem 2 – Rising Peak Demand Threatens Reliability	
Peak demand for electricity is rising faster than demand in non-peak periods, resulting in a system that is less stable during peak periods and seasons. Reliability of the distribution system is threatened during peak periods. Transmission systems are approaching maximum capacity during peak demand, threatening reliability. The transmission system has not been expanded in many years, resulting in congestion.	System reliability is strained by exponential expansion of market transactions between generators, transmission operators, the ISO and customers. The transmission system, which has not been expanded in many years, operates less efficiently. California's electricity system is susceptible to seismic, wind and storm damage.
Problem 3 – Balance is Needed Between Electricity and the Environment	
Electricity use is increasing with potential adverse impact on the environment. The cumulative environmental effects caused by electricity generation, transmission and distribution are not adequately understood. There are inadequate methods and tools for predicting, measuring and mitigating the environmental impacts of electricity generation, transmission and distribution. Increasing use of fossil fuels for electricity generation will increase emissions of greenhouse gases.	There are missed opportunities for converting waste to electric power, while reducing the environmental impacts of industrial, agricultural and forest management processes that are expensive and electricity-intensive to mitigate. In dispatching capacity, the Power Exchange and Independent System Operator generally do not consider the environmental impacts of available energy sources other than NOx credits. Efficient buildings have caused problems with indoor air quality.
Problem 4 – Market Uncertainties and Price Volatility are Occurring	
The deregulated electricity market is not operating optimally. Demand growth is exceeding new generation. Peak demand is rising faster than base demand.	With increased use of natural gas for generation of electricity, California is becoming more vulnerable to fuel supply interruptions.

3.3 Step 2: Determine Whether Current RD&D Activities are Adequately Addressing California's Major Energy Problems

Now that California's major energy concerns have been identified, it is important to determine whether a variety of existing and planned RD&D efforts (in the PIER and elsewhere) are adequately addressing these concerns. By carefully reviewing these ongoing RD&D efforts, we ensure that future PIER funding specifically targets those activities of greatest interest to California that are not adequately addressed at the present time.[41] Arthur D. Little, Inc. (ADL) reviewed current RD&D projects undertaken by other major research organizations as well as projects currently underway within the PIER Program.[42] In the following subsections, we summarize and highlight what was found.

3.3.1 Status of Existing PIER Projects in Addressing Priority Problems and Program Objectives

To determine the status of existing PIER projects in addressing priority problems and program objectives, the staff reviewed all current PIER projects and identified the problems of concern and the PIER objectives addressed by each project. Key conclusions from this analysis include the following:

- There appear to be several problems of concern to California that have received little or no PIER funding to date. These problems include (1) transmission systems approaching maximum capacity during peak demand, threatening reliability; (2) transmission systems not expanded in many years, resulting in congestion; and (3) increased use of fossil fuels for

---

[41] We anticipate that this type of comparative review will be conducted on a regular basis as the PIER Program updates its plans in the future. Such reviews will evaluate existing RD&D activities in light of both energy issues of concern to California and the public benefit objectives specified for the PIER Program. In this way, we expect to identify those RD&D activities which can provide the greatest public benefits to California, while avoiding PIER Program expenditures for efforts already being adequately conducted by other RD&D institutions.

[42] In addition to the PIER Program itself, we have reviewed work currently being conducted or planned at key RD&D institutions in the United States including the U.S. Department of Energy (DOE), the National Laboratories (such as Oak Ridge National Laboratory [ORNL] and the National Renewable Energy Laboratory [NREL]), the Electric Power Research Institute (EPRI), the Gas Technology Institute (GTI [formerly GRI]), and other federal and state organizations (e.g., the Department of Defense [DOD], Environmental Protection Agency [EPA], New York State Energy Research and Development Authority [NYSERDA], California Air Resources Board [CARB]). It is important to note that all of these RD&D institutions work closely with a wide variety of both national and international participants from the private, regulated and the public sectors. The results of the ADL reviews are summarized in the following set of documents: PIER Program Planning-Gap Analysis Phase, Buildings, Arthur D. Little, Inc., October 12, 2000; PIER Program Planning-Gap Analysis Phase, Industrial, Arthur D. Little, Inc., October 12, 2000; PIER Program Planning-Gap Analysis Phase, Environmentally Preferred Advanced Generation, Arthur D. Little, Inc., October 12, 2000; PIER Program Planning-Gap Analysis Phase, Renewables, Arthur D. Little, Inc., October 12, 2000; PIER Program Planning-Gap Analysis Phase, Environmental, Arthur D. Little, Inc., October 12, 2000; and PIER Program Planning-Gap Analysis Phase, Strategic, Arthur D. Little, Inc., October 12, 2000. The documents are available for viewing in the Commission's Dockets Office under Docket Number 01-PIER-1.

electricity generation leading to increased emissions of greenhouse gases. Problems of concern, such as these, need to be carefully evaluated to determine whether additional PIER funding is needed and/or whether the regulated and competitive markets are already adequately addressing these problems, or *indirectly* addressed by other PIER projects or by other RD&D institutions.

- There are several high priority problems of concern to California that may not be *adequately* addressed based on the number of projects and funding allocated to date in PIER Program. Specifically, these include (1) the reliability of various distribution systems which are threatened during peak loads; (2) the cumulative adverse environmental impacts caused by electricity generation, transmission, and distribution, which are not adequately understood; and (3) the deregulated electricity market, which is not operating optimally at the present time.
- Two PIER Program objectives—strengthening the economy and enhancing consumer choice—appear to be under-emphasized in currently funded projects. These objectives need to be evaluated further, and policy decisions need to be made regarding their future level of emphasis. For example, while strengthening California's economy is an important overall public benefit objective, perhaps this should be viewed as a subsidiary objective because virtually all PIER projects are expected to benefit the economy, directly or indirectly. Similarly, the objective of enhancing consumer choice is probably addressed by many (or most) of the PIER RD&D projects that address other objectives, such as reducing the cost or environmental impacts of the electricity system.
- Some problems of concern to California may require more projects and/or more funds to be effectively addressed than other problems. Thus, careful judgment from each of the PIER subject areas will be required in the development of future PIER RD&D strategies.
- Each of the six PIER subject areas is currently in differing stages of development that will evolve further as these subject areas procure more projects and encumber more funds. (For example, the Buildings Energy Efficiency subject area, developing rapidly within PIER, has funded more than twice as many projects as any other PIER subject area to date.) We need to determine whether current funding imbalances between the different subject areas should be addressed actively, as a matter of policy, or whether these differences are acceptable.

3.3.2 Status of Other Institutional RD&D Efforts in Addressing Priority Problems

To determine the status of other RD&D efforts in addressing California's priority problems and PIER Program objectives, ADL identified external projects that addressed the major problems of concern to California. The ADL results revealed that many non-PIER research projects are addressing energy problems of concern to California to some degree. ADL also evaluated whether PIER projects are currently addressing problems and objectives *not adequately addressed* by non-PIER projects. The results of this analysis indicate that existing PIER projects are not duplicating RD&D being done elsewhere. With these results in mind, the PIER Program is now well equipped to identify those research strategies that are likely to yield the greatest benefits for California citizens and ratepayers in the future.

3.4 Step 3: Select RD&D Strategies to Address the Major Energy Problems in California

This section describes each of the four major energy problems that are currently of greatest concern to California and the possible impacts to citizens and ratepayers if these problems are not addressed in an effective manner. We then identify and explain specific RD&D strategies that the PIER Program will support to address these problem.

Because there are significant interrelationships among the problems of highest concern to California, some of the strategies and RD&D activities identified below address more than one of these problems. It has become evident that the best solutions are *integrated* across technical disciplines and subject areas. In addition, by undertaking various activities and projects across multiple subject areas, the PIER Program improves the probability of finding solutions and having a significant impact on the problems.

3.4.1 Problem #1 – Electricity Demand Has Been Increasing Faster than Supply

When electricity restructuring was first discussed in the early 1990s, California had an adequate reserve of generating capacity. Now this adequate capacity reserve no longer exists. Over the past decade, nearly 4,000 MW of additional generating capacity has come on line in California (1,500 MW requiring Commission approval), and some older units have been retired. Recently, nine new generating units have received Commission permits and many more new units have applied. However, the generation additions have occurred over a period when demand has risen sharply, and market dynamics and other factors have restricted effective supply, driving up energy prices.

3.4.1.1 Cost if the Supply and Demand Problem is Not Addressed [43]

The Commission projects an increase in electricity demand in California from 256,000 GWh in 2000 to 310,000 GWh (21 percent increase) by 2010, and to 378,000 GWh (48 percent increase) by 2020. [44] Under business-as-usual conditions, capacity would be added gradually to match electricity demand, and prices might rise modestly. Events that have occurred during the second half of the year 2000 show, however, that combinations of extreme departures from normal weather in the western part of the U.S., coupled with changes in how suppliers operate under deregulated conditions, can create market dislocations with severe economic penalties.

---

[43] Analysis of the costs of not addressing California's electricity-related problems has been continuing during the development of this report. It is not yet complete at the time of the report, but results to date serve as the basis for cost estimates presented in this section.

[44] California Energy Commission, California Energy Demand, 2000-2010, Staff Report P200-00-002, June 2000. This forecast assumes that new electricity supplies will be added at a rate to meet demand.

Figure 1 shows that wholesale electricity revenues increased dramatically in the second half of 2000 compared to what they would have been had 1999 electricity prices prevailed. The cumulative increase in wholesale revenues for the year was over $15 billion ($20.5 billion compared to $5.3 billion). Part of the increase was passed on to electric customers, but much of the increase was absorbed by utility shareholders as a result of the rate freezes implemented as part of the deregulation process.

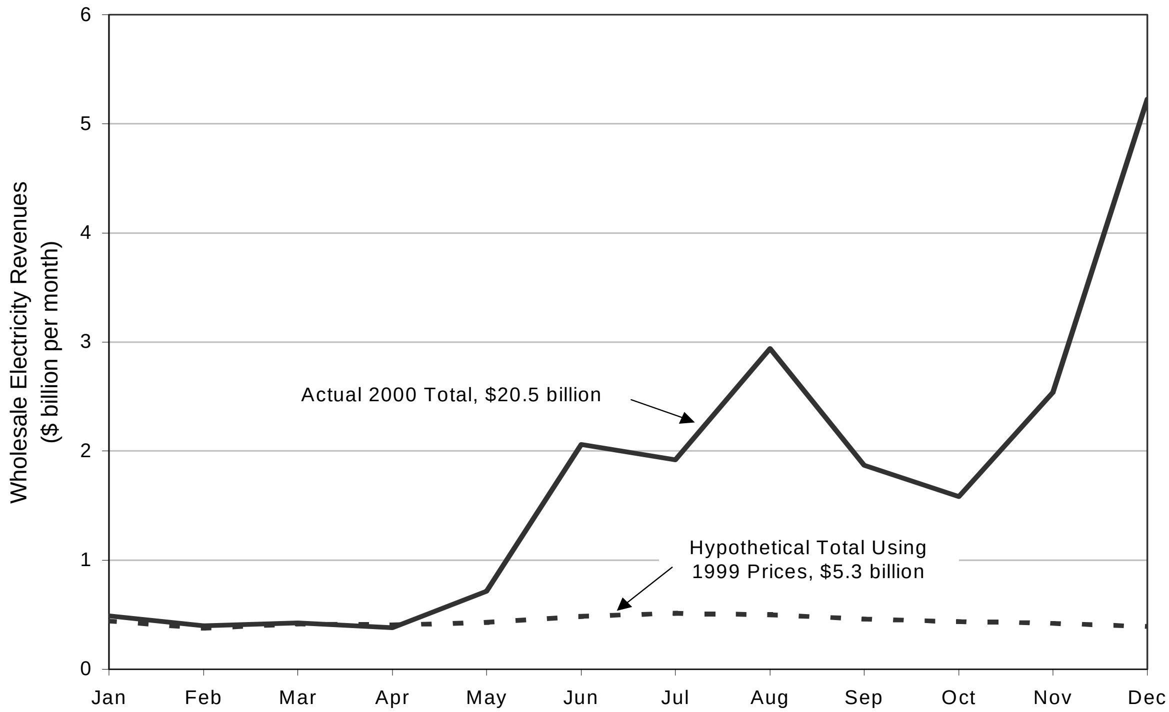

Figure 1. California's Annual Wholesale Electricity Revenues Jumped by a Factor of Four from 1999 to 2000

Note: Total dollar values (represented by areas under the curves) are the annual procurements by the utilities through the PX. Dashed line is hypothetical, based upon 1999 prices applied to 2000 procurements. Solid line represents actual 2000 procurements.

Source: CalPX Day-Ahead Unconstrained Market Hourly Average Prices and Daily Volume, January 4, 2001.

The increases in demand will also require additional electrical generation, which will pose further environmental burdens on California. Because virtually all new generation capacity is expected to be natural gas-fired, the additional air emissions are modest. However, the water use for cooling electric power plants in California will increase substantially as new generation is added, growing to 4.4 times 1995 levels by 2004 and to nearly 18 times the 1995 levels by 2020. [45]

[45] At these levels, the amount of water used to cool power plants is small in comparison to overall water use, which is dominated by agricultural use of water, but it should be expected that increased use of

Customer requirements for more reliable and higher quality power are also increasing. It is estimated that in 1999 inadequate power quality and interruptions in electrical service cost California industries $3-6 billion in lost product and damages to equipment and inventory. By 2004, expenditures by California industries for backup power systems and power-conditioning systems to improve power quality (voltage maintenance, surge protection, reduction of harmonics, etc.) are expected to reach $4 billion per year. In addition, poor reliability and power quality could dampen the growth of sensitive industries if other regions are able to offer better reliability and quality.[46]

Other factors that were not quantified may add to the potential costs discussed above. For example, early retirement of existing nuclear and hydro plants is quite possible. Such early retirements would further add to the required additions of natural gas capacity with further increases in power costs, additional emissions, and additional water use. Growing dependence on natural gas also could leave California increasingly vulnerable to gas price increases and/or interruptions of natural gas supplies. Even with the current expected additions of natural gas-fired generation capacity, additional gas pipeline capacity coming into California will be required by 2009 in order to maintain projected natural gas demands. Finally, actions that may be undertaken to reduce emissions of greenhouse gases (see the discussion in Section 3.4.3.1) may increase the difficulty of siting and the costs of owning and operating new fossil-fueled power stations in the future.

3.4.1.2 Strategies to Address the Supply and Demand Problem

Four possible strategies for addressing the supply/demand problem are:

- Increase electricity supply
- Decrease electricity demand through efficiency improvements
- Match supplies more closely to demand
- Provide consumers with better information, decision tools and energy system components.

Specific activities that the PIER Program might fund in each of these strategic areas are described below.

3.4.1.2.1 Increase Supply

The PIER Program can help increase the supply of electricity to meet California's future needs by developing (1) small fossil and renewable generation technologies that will provide improved power quality and reliability and (2) information and regulatory tools to mitigate the environmental impacts associated with new generating facilities.

---

water to cool power plants will increase the competition for water with the agricultural, industrial and residential sectors, and water prices could therefore rise.

[46] If the growth rate of California's hi-tech industries were to fall by 1 percent (from the expected 17 percent rate of growth to 16 percent) between now and 2004, California would lose 88,000 jobs and $5 billion/year in payrolls, and would also lose about $8 billion/year in product exports.

Substrategy 1 to increase supply: *Support small fossil and renewable generation technologies that will provide improved power quality and reliability by the following:*

- Developing small fossil and renewable power generation options that can be sited nearer customer load centers
- Documenting and communicating the benefits of using these technologies to regulators and customers
- Removing barriers to the adoption of these systems.

The increased use of such small generators will provide a less expensive means than central generation for providing the 99.9999 percent reliability that is required by California's high-tech industry. It will also reduce the impacts and costs of distribution outages, and the investments that many California industries might otherwise have to make to ensure adequate power quality and reliability.[47]

To ensure consistency with various public interest objectives, the PIER Program will develop small generating technologies that (a) have reduced environmental impact, (b) reduce California's dependence on natural gas for power generation, and (c) provide additional benefits through improved integration of power systems into customer applications.

We also seek to ensure that benefits from this effort actually reach the market place, and are appropriately balanced over the near-, mid- and long-term time horizons.[48] Near-term benefits (five years or less) are expected from the facilitation of the use of small fossil-fueled distributed generators, integration of these units into the power grid, and minimization of the environmental and safety impacts. Mid-term benefits (five to ten years) are expected through important incremental improvements and the increased use of existing small generating technologies. Long-term benefits (over ten years) include the development of renewable and very clean fossil technologies that further reduce the environmental impacts of distributed generation sources and reduce California's dependence on natural gas.

Substrategy 2 to increase supply: *Develop new science, information and related regulatory tools to mitigate the environmental impacts and facilitate the siting of large generating plants.*

As noted in Chapter 2, the demand for electricity has been growing faster than electricity supply in recent years. Further, population and economic growth in California's neighboring states have produced similar growths in demands for electricity. If these trends continue, prices for electricity will rise, California's capacity will be strained further by growing demands in the region, and pressure will mount to increase large generation capacity. The pressure to increase

---

[47] California industry suffers losses of $3-6 billion / year because of inadequate power quality and short-duration power outages, and the high-tech industry in California alone is expected to spend about $4 billion / year for backup generators and power conditioning systems to ensure adequate quality and reliability to meet its needs. This substrategy will help to reduce these costs to California industry.

[48] For purposes of this report, RD&D activities are expected to begin producing tangible benefits for the public in five years or less (near-term), five to 10 years (mid-term), or more than 10 years (long-term.) It is important to note that public benefits are expected to continue to increase after the initial time frame in which they are first felt in the marketplace.

capacity could lead to the relaxation of environmental standards, which would conflict with Californians' desire for a clean environment. The PIER Program's strategy for reconciling potentially conflicting desires for more electricity and a clean environment is to provide information, models, mitigation methods, and other tools to identify and facilitate environmentally acceptable generation supply options.

PIER activities in this area will produce near-term benefits by providing objective analyses and data to support regulatory decision-making and rulemaking and to facilitate environmentally friendly operation of hydro facilities, and siting and operation of large fossil plants. Mid- and long-term benefits will result from PIER activities that develop clean renewable technologies, options for a transition to a hydrogen fueled economy, and selected environmental technologies to mitigate impacts from generation and delivery systems.

3.4.1.2.2 Decrease Demand

New capacity additions within California will service some of the increased demand for electricity. Additional electricity imports from neighboring states, if available, will aid as well. However, it will be difficult for capacity growth alone to keep up with growing demand.[49] Therefore, a second PIER strategy for addressing the supply and demand problem is to develop technologies that will reduce the demand for electricity.

This demand-reduction strategy focuses on residential and commercial buildings and on industrial, agriculture and water utilities.

Residential and commercial buildings account for about two-thirds of total electricity consumption **(Figure 2)**. Industry, agriculture, and water utilities account for 28 percent of total electricity use, with agriculture alone accounting for seven percent. The buildings subject area leverages programs undertaken by DOE, EPRI, GTI, and others. Because of the diversity of the industrial sector, PIER activities in this area will include working with several partners, including U.S. DOE's Office of Industrial Technologies, EPRI, GTI and various California industry associations. PIER activities for improving energy efficiency in agriculture and water utilities, both of which are very important to the economy of California, will include collaborating with the University of California, water utility associations and EPRI.

[49] Difficulties in siting large new generating stations are likely to continue because of environmental concerns, and demand growth in neighboring states will compete with California for supply additions. PIER activities that develop clean fossil and renewable distributed generation technologies will contribute to electricity supply, beginning in the near term as existing technologies begin to penetrate the market, but large impacts will not be seen until the long-term, when the technologies have had ample time to reach target market levels.

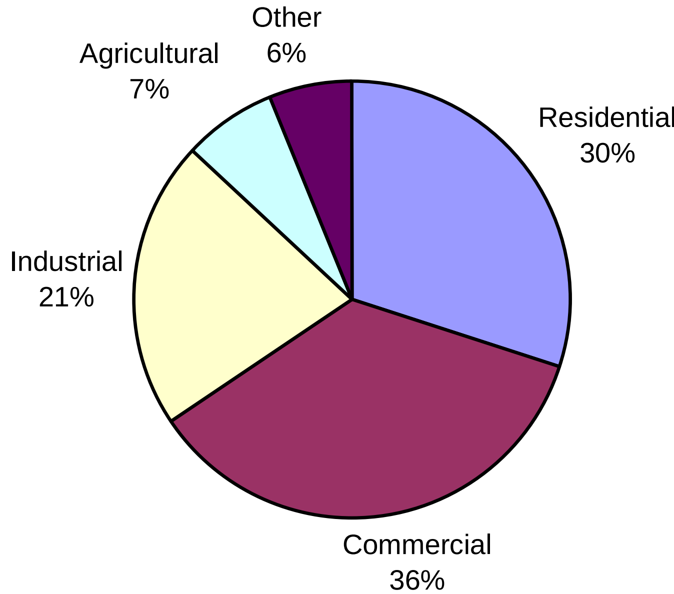

Figure 2. Electricity Use by Sector in Year 2000 (279 TWh)

Source: California Energy Demand: 2000-2010, Staff Report P200-00-002, June 2000.

Substrategy 1 to decrease demand: *Reduce electricity consumption in California buildings by (a) improving building design, construction, and operation, and (b) developing higher efficiency technologies to provide major electricity services such as cooling and lighting.*

This substrategy will begin to create benefits for existing building applications in the near-term, and the benefits will grow over time. Near-term benefits will be limited by the time required for market penetration of new technologies and practices. The leveraging of PIER funds by external funds will increase the benefits resulting from PIER buildings programs. Significant benefits from activities designed to increase efficiency in new buildings are expected to be seen in the long-term.

Specific activities of the PIER buildings program that will have near- and mid-term benefits in existing buildings include the development of high efficiency energy systems and equipment and the development of approaches tailored to increase the efficiency of energy use in low-income and multifamily buildings. PIER buildings programs provide long-term benefits by developing more efficient building design and construction methods and technologies that integrate energy efficiency with other desired attributes that increase occupant productivity, comfort, and well being. They also provide information to promote the purchase of high efficiency technologies by building owners and occupants.

Substrategy 2 to decrease demand: *Increase the efficiency of electricity-using technologies and processes in California's industrial, agricultural and water utilities.*

The industrial sector is very diverse, and there is a relatively smaller body of in-house research upon which the PIER Program can leverage its limited funding to achieve desirable efficiency improvements. To maximize the benefits to California of its limited resources, the PIER Program will focus and leverage its activities with related work being done by the DOE's Office of Industrial Technologies, the national laboratories, EPRI, and GTI. This effort will primarily focus on the energy efficiency and reliability for industries that are critical to California economy, such as electronics, petrochemicals, and food processing.

- For petrochemicals, likely PIER focuses include environmentally sound, energy efficient processing of petrochemical products and refinery designs.
- For electronics, likely PIER focuses include reduction in the energy intensity and developing site-specific power quality options.
- For the food and agriculture industry, likely PIER focuses include the development of more efficient processes (such as harvesting, lighting, climate control, water pumping, dehydration, and cold storage), more efficient environmental remediation, and improved energy conversion.

Benefits from these activities are expected in the near- to mid-term, as anticipated technology improvements are primarily incremental in nature and can be completed within a few years.

Water quality and quantity are also a major concern in California, and this is important to the electricity supply / demand problem because pumping water, purifying water, and disposing of wastewater are energy-intensive activities. The PIER Program will take advantage of opportunities to reduce electricity demand in this area while also helping to ensure that Californians have an adequate and clean supply of water. Activities undertaken in this area are also expected to realize benefits in the near- to mid-term.

3.4.1.2.3 Match Supplies More Closely to Demand

Even if California's projected electricity supply were adequate to meet most projected demands, matching electricity supplies to demand remains a very challenging problem. Nowhere is the need for extremely high reliability and high quality electricity more important than in the electronics and computer industry of this state. Many companies in this industry are intolerant of even the most minor of imperfections in either the quality or the reliability of electricity (e.g., requiring power that is reliable 99.9999 percent of the time, while today's power grid today is only 99.9 percent reliable). This industry is the fastest growing industry in California and is crucial to California's future. As noted above, the cost to California industry of normal short-duration outages is $3-6 billion per year, and the California high-tech industry is spending an estimated $4 billion per year to maintain acceptable power quality and reliability.

PIER funded activities will attack these power quality and reliability problems by (a) improving the transmission and distribution systems and (b) providing options that better match electricity technologies to customer needs.

Substrategy 1 for matching supply and demand: *Improve the transmission and distribution systems.*

PIER funded activities will strive to increase the reliability and efficiency of California's electricity delivery system by facilitating the location of small generators near electricity loads to reduce the distance that electricity must be transported (reducing resistance losses) and minimize grid congestion. These efforts will have significant near-term impacts locally where supply problems are caused by grid limitations. In addition, technologies that allow customers to receive better information about their use of power and its effect on the grid, and to respond to that information, also are important in solving reliability problems.

Substrategy 2 for matching supply and demand: *Develop options that better match electricity technologies to customer needs.*

PIER funded activities will provide information and improved technologies that can create more pathways for generation supplies to reach customers, hence, increasing system resiliency. These information products will begin to produce benefits in the near-term and will show significant benefits in the mid-term. In the long-term, additional benefits will also result from PIER activities that develop technologies (fossil and renewable) that are integrated into customer processes and connected to the grid.

3.4.1.2.4 Develop Better Information, Decision Tools and Energy System Components for Consumers

The supply / demand problem is compounded, in part, because electricity consumers often do not have adequate data to make informed decisions about their electricity use. Even when information is adequate, the capability of energy technologies and the power grid to let customers act on their preferences often does not exist. The PIER Program will develop science and technologies designed to provide customers with full information about their energy use, and the tools to act on customer preferences.

Substrategy 1 for better information and tools: *Develop technologies to provide real-time or near real-time feedback to customers about their electricity use, electricity prices, and the performances of their energy systems in order to enable them to respond in real time to optimize electricity use for minimum cost.*

PIER funded research in this area can have significant impact on how customers use electricity and how those uses affect the grid in the mid- and long-term as customers gain access to and learn to use information about their use of electricity. Examples of research in this area include inexpensive real-time meters, as well as HVAC and appliance monitoring technologies that inform customers about how the current operation of that device impacts customer electricity use.

Substrategy 2 for better information and tools: *Develop energy system design tools, analysis tools, and data that enable the selection of options from a wide array of choices.*

Information about a customer's electricity usage is of little value unless the tools to act on that knowledge by changing usage patterns are also available. The PIER Program will support development of better tools to control energy systems and better design and technology selection tools that allow customers to tailor energy choices to their specific situations and preferences.

The development of these tools will be a major focus for PIER Buildings and Renewables subject areas, where such tools are most lacking and energy use is most diverse. PIER funding will focus, among other things, on simplified building and energy system simulation and technology selection to allow product developers, building designers, and customers to customize their energy choices to match their needs. Renewable technologies offer customers significant non-energy benefits, which depend on customer use patterns, and the PIER Program will include several major activities to provide tools for customers to identify and evaluate the benefits of renewables in their own environment. These developments can all begin to generate customer and electricity system benefits in the mid-term. In the longer term, PIER programs will also focus on the integration of advanced technologies and design / analysis tools that allow more customized energy choices by customers.

3.4.2 Problem #2 – Rising Peak Demand Threatens Reliability

Rising peak demand for electricity results in higher and more volatile electricity prices, as well as increased potential for costly interruptions in service. Peak demand on hot summer days is currently approaching the capacity limits of California's generation and delivery system, and peak demand for electricity is rising even faster than demand during non-peak periods. The peak electricity demand in California is expected to grow by 18 percent between 2000 and 2010, from approximately 56,000 megawatts to approximately 66,000 megawatts. **Figure 3** shows this projected growth while **Figure 4** shows historical peak load growth.

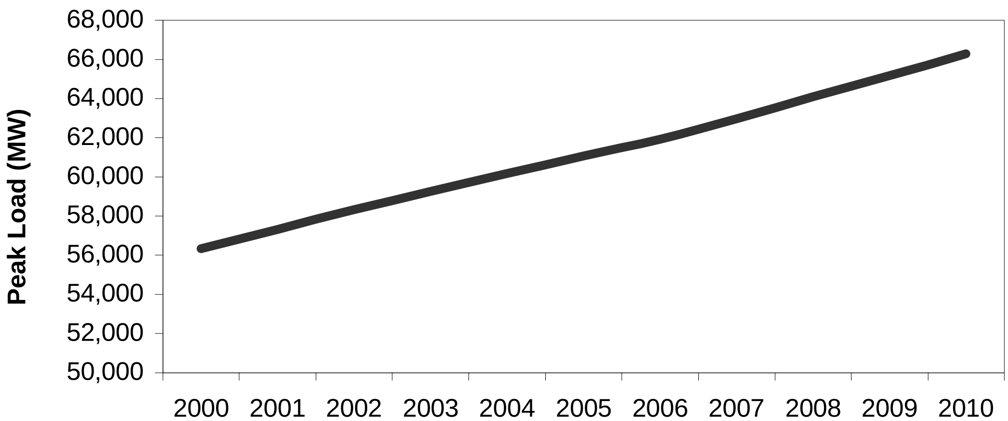

Figure 3. Projected Growth of California Peak Electricity Demand

Source: *California Energy Demand: 2000-2010*, Staff Report P200-00-002, June 2000.

The electricity generation and delivery system needs to be built to handle peak loads, but this often results in large capital costs for portions of the system that then sit idle during non-peak periods. Alternatively, customers need more effective techniques to manage their peak loads, which will also result in a smoother load factor for the system. High peak loads also threaten the reliability of the distribution system, require the use of less environmentally favorable generation sources, and stress the capabilities of the ISO. The transmission system, which has not been updated or expanded in many years, is threatened with reliability problems resulting from congestion during periods of peak demand.

As with electric systems throughout the country, the reliability of the system is also threatened by storms, fires, and flood damage. In California, there is the added threat of catastrophic failure from earthquakes.

3.4.2.1 Cost if Rising Peak Demand is Not Addressed [50]

In 1998, California's in-state generation capacity was 53,700 MW, and an additional 5,000 MW of out-of-state capacity was available to meet California's needs, for a total of 58,700 MW of available capacity. However, recently in-state capacity *additions* have fallen behind peak demand growth rates. Peak loads have increased by over 5,000 MW since 1995, while in-state capacity additions have been less than 900 MW **(Figure 4)**. Load growth is also very high in other southwestern states, and it is expected that competition for the 5,000 MW of out-of-state capacity will increase in future years. (**Figure 3** shows the projected peak load growth.)

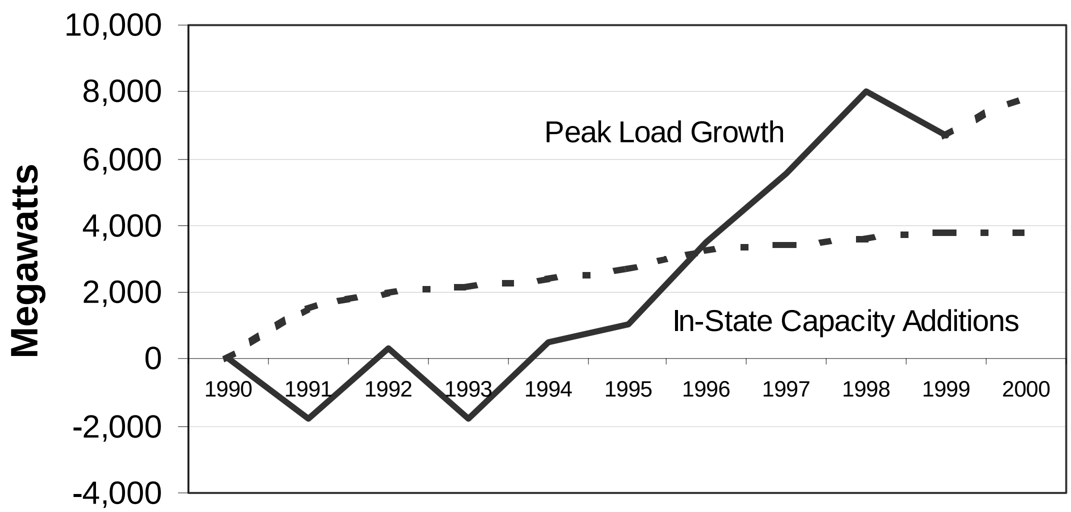

Figure 4. California Cumulative Electric Capacity Additions vs. Peak Load Growth 1990-1999

Sources: California Energy Demand: 2000-2010, Staff Report P200-00-002, June 2000.California Energy Commission Power Plant Database, June 22, 2000.

Approximately 6,530 MW of new capacity in California is expected to be on line by 2003, and another 6,900 MW is expected to come on line in the rest of the West. However, peak load plus a 5 percent reserve margin in California is currently expected to grow to 58,200 MW by 2004, to 64,100 MW by 2010, and to 76,000 MW by 2020. Currently expected capacity additions would be just adequate to prevent Stage 2 Emergencies (see notes to Figure 5 for a definition) in 2004,

---

[50] Analysis of the costs of not addressing California's electricity-related problems has been continuing during the development of this report. It is not yet complete at the time of the report, but results to date serve as the basis for cost estimates presented in this section.

provided there were no early retirements of nuclear or hydro plants and no unplanned outages at peak times. As events of the year 2000 have demonstrated, extreme weather events, or sequences of such events, can and will generate major supply problems and significant economic dislocations. As discussed in Section 3.4.1.1, the combination of events during the latter half of 2000 increased wholesale electricity revenues by $15 billion over what they would have been had 1999 electricity prices prevailed. Furthermore, the number of power emergencies that were declared by the California ISO in the year 2000 was unprecedented, increasing to over eight times the total declared emergencies in 1998 or 1999 **(Figure 5)**.

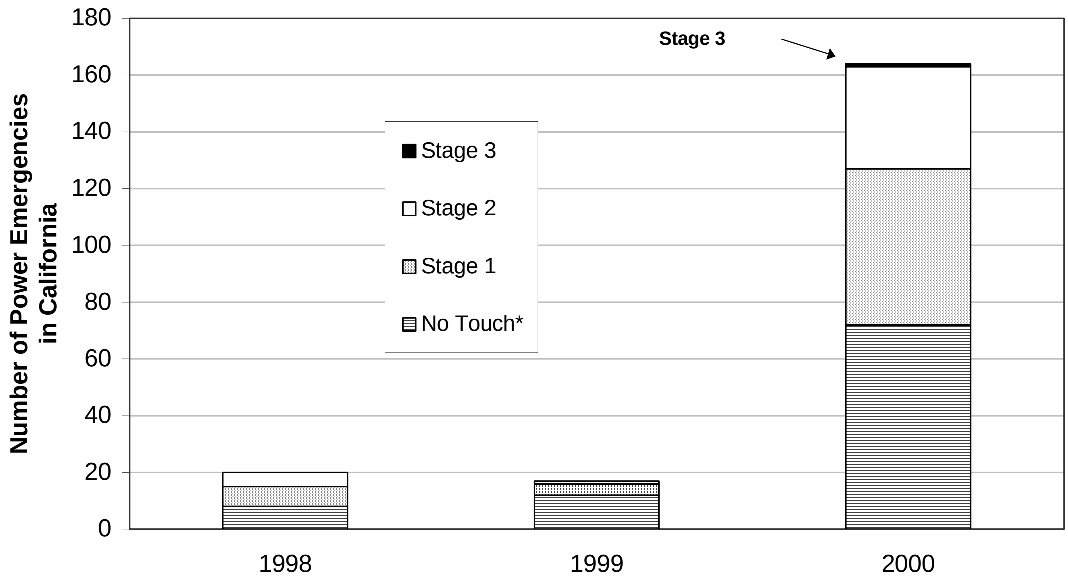

Figure 5. Sudden Increase in Declared Power Emergencies

Note: Definitions of Power Emergencies:
No Touch periods. The ISO demands that generators refrain from downtime for maintenance.
Stage 1. The ISO determines that an operating reserve shortfall is unavoidable or forecast within two hours.
Stage 2. The ISO determines that the operating reserve will fall below 5 percent.
Stage 3. The ISO determines that the operating reserve will fall below 1.5 percent.

Source: California Independent System Operator Web Site, http://www.caiso.com.

Additional capacity will be required after 2004 in order to meet expected loads. The annual costs of owning new natural gas peaking capacity are estimated to be $50 to $80 per kW-year.[51] Based on these costs, the cost to California electric customers of the added capacity needed to meet peak loads will be $270 million to $520 million per year in 2010 and $860 million to $1.1 billion per year in 2020. However, siting constraints and competition from neighboring states

[51] Air Pollution Emission Impacts Associated with Economic Market Potential of Distributed Generation in California, June 2000, A report prepared for the California Air Resources Board and the California EPA by Joseph Iannucci, Principal Investigator, and Distributed Utility Associates.

for access to new capacity may make inaccessible this relatively low-cost option for meeting the electricity capacity needs associated with demand growth.

According to reliability statistics from the California Public Utilities Commission (CPUC), electricity customers in California averaged 175 minutes per year of outages over the 1990-99 period if major events (e.g., earthquakes) are excluded. The average number of outages of five minutes or more duration was 1.68 per year, and the total number of outages, including momentary outages of less than five minutes was 5.35 per year. There is no evidence that the frequency or duration of such outages has increased between 1990 and 1999. If we assume that the outage frequencies and duration do not increase in future years, the expected cost to California electric customers will be $2.4 billion/year in 2004 and will rise to $3.3 billion/year by 2020 as electricity use increases. When costs associated with inadequate power quality are included, annual expected costs rise to $3-6 billion as noted in Section 3.4.1.1.

Major outages associated with natural disasters and major transmission system failures were excluded from the outage costs above. A major transmission system failure in August 1996 cost the California economy an estimated $1-3 billion in lost productivity and product losses.[52] If planned capacity additions in California and the rest of the West are not put in place, the probability of such an outage would rise from once every 40 years to one every year.[53] This increase in probability is associated with a decrease in reserve margin from seven to zero percent.

3.4.2.2 Strategies to Address the Peak Demand and Reliability Problem

The PIER Program will pursue the following three strategies to address the peak demand/reliability problem: (1) increase the utilization of local generation technology, (2) reduce peak loads or shift part of these loads to off-peak periods, and (3) improve operation of the transmission and distribution system.

3.4.2.2.1 Increased Use of Local Generation Technologies

A unique feature of electricity generation in California is the use of DG. According to the Energy Commission's Power Plant Database, as of April 1999, DG provided about six percent of California's system peak. In addition, the strategic use of small renewable or natural gas fueled power generation technologies on-site or at substations can provide significant relief from transmission congestion problems and provide increased reliability for local electric customers.

However, DG technologies are relatively new and there are significant barriers to the acceptance of small generation technologies by users and to their integration into the electrical grid. The PIER strategies to advance DG systems can be categorized into two substrategies. First, PIER projects will provide objective science information to improve the general perceptions and acceptance of on-site and DG systems. Second, PIER projects will improve

---

[52] Maintaining Reliability in a Competitive U.S. Electricity Industry, U.S. Department of Energy Sept. 29, 1998, http://www.hr.doe.gov/seab/electsys.html.

[53] High Temperatures and Electricity Demand, an Assessment of Supply Adequacy in California: Trends and Outlook, California Energy Commission, Report P300-99-004, July 1999.

technologies in on-site and DG systems to reduce costs, increase efficiency, reduce emissions, and improve system safety. These system improvements will help make systems more valuable to customers and will help to increase customer acceptance.

Substrategy 1 to increase local generation: *Provide science information, which will increase the acceptance of, advanced renewable and gas-fired on-site and DG technologies.*

There are often uncertainties associated with the use of any new technology, and these uncertainties translate into risk to anyone who wishes to use them. Small renewable and advanced fossil-fueled electricity generators are no exception to this rule, and the risks to users are compounded by uncertainties about future electricity costs and future power grid operation rules. Although RD&D activities cannot eliminate all the institutional and economic risks, they can help to eliminate risks associated with uncertainties as to technology costs, performance, and rulemaking. The PIER Program can provide a source of trusted, unbiased information to potential product users by field testing technologies and publishing the results, documenting the benefits that will accrue to adopters, and contributing to industry-accepted safety, technology testing, and evaluating standards and protocols. PIER funded research will include field tests of small generators in both grid-connected and in stand-alone situations.

The results from PIER efforts should provide some near-term benefits as customers accept existing DG technologies. In the mid-term, benefits from increased acceptance of existing DG technologies will become more significant. Full benefits from the increased use of renewables will be felt in the long-term.

Substrategy 2 to increase local generation: *Improve benefits of on-site and DG systems by reducing costs, increasing efficiency, reducing emissions, and increasing system safety.*

Where technology capabilities fall short in crucial ways that impede customer acceptance, the PIER Program will work to improve the technologies. PIER funding will include activities to reduce component and system costs of small generation technologies as discussed in the Increase Supply strategy of Problem 1, above. In addition, the integration of small fossil-fueled or renewable generators with other systems where the integrated system costs less than the individual system could reduce the generators' effective costs. For example, photovoltaic systems may be integrated with structural components of buildings or generation technologies may be integrated with storage technologies. Integration of generator technology with storage technology not only reduces costs, but also improves the reliability, availability, and dispatchability of small generation technologies.

PIER RD&D will also strive to increase system safety and decrease emissions. PIER may develop control and communication systems and dispatch protocols for the operation of distributed generation (DG) technologies to ensure the safety of utility employees and the reliability of the system. In the emissions area, PIER is exploring the requirements for a successful hydrogen delivery system.

Near- and mid-term benefits from PIER activities that fall under this substrategy will result from information activities and field tests that increase customer confidence and incremental technology improvements (e.g., the modification of existing grid interconnect and communications systems to meet California requirements). Long-term benefits will result from the development of advanced generating technologies, integrated technologies, and possible implementation of a hydrogen energy economy.

3.4.2.2.2 Reduce Peak Demand or Shift Peak Demand to Off-Peak Periods

The reliability of the electric system can also be improved. Moderating peak loads and smoothing the load curve can decrease transmission congestion. Peak loads can be moderated either by increasing end-use efficiency, which reduces the peak demand as well as the overall level of demand, or by shifting a portion of the peak demand to off-peak periods through the use of storage or load management technologies.

Most of the PIER activities previously discussed under the Reduce Demand strategy associated with Problem 1, above, will also contribute to solving California's peak load problem. In addition, special efforts to increase the efficiencies of specific technologies may be warranted by the contributions of these technologies to peak loads. These particularly important technologies are discussed in Substrategy 1 below. Alternatively, a portion of the peak demand may be shifted to off-peak periods through the use of storage or load management technologies. Several significant opportunities for load-shifting technology innovations have been identified as good candidates for PIER funding. These are discussed in Substrategy 2, below.

Substrategy 1 to reduce peak demand: *Develop high-efficiency end use technologies for areas that are major contributors to peak loads.*

Figure 6 shows the contribution of various sectors to peak loads. Notice that residential and commercial buildings contribute over two-thirds of the peak load. Further, air conditioning and lighting are the major contributors to peak electric loads in buildings. Residential and commercial air conditioning account for 29 percent of the California peak electricity load, and commercial lighting accounts for an additional 11 percent. These technologies have been singled out for special efforts because of their contribution to building peak loads.

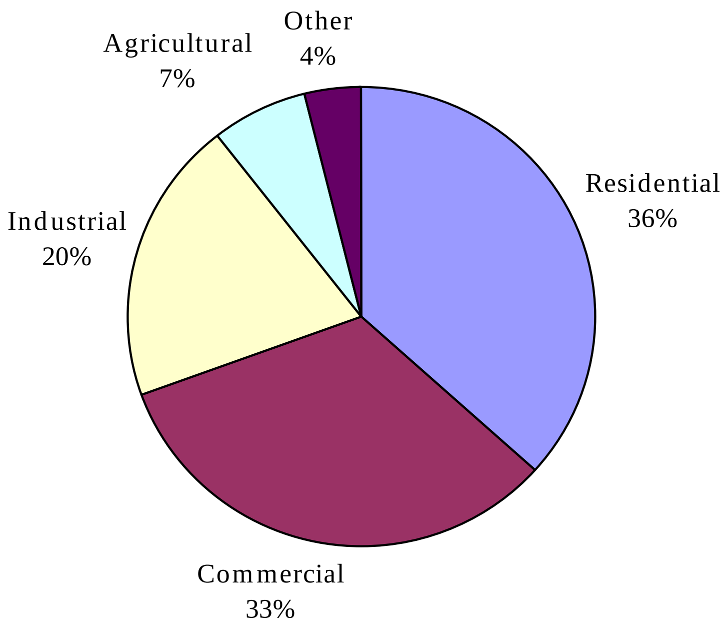

Figure 6. Sector Contributions To Peak Demand In 2000 (56,000 MW)

Source: California Energy Demand: 2000-2010, Staff Report P200-00-002, June 2000.

Specific examples of opportunities that PIER will explore to reduce building peak loads by increasing efficiency include the development of compressor-less cooling technologies or more efficient compressor technologies to reduce air conditioning loads, the development of more efficient lighting technologies, and the integration into the building envelope of renewable technologies whose peak electricity production generally coincides with peak building loads. Benefits from these programs will begin in the mid-term and will be fully realized only in the long-term.

Substrategy 2 to reduce peak demand: *Develop technologies to allow customers to shift a portion of the peak load to off-peak times.*

PIER activities to develop load management and shifting capabilities for electricity customers include (a) communications and metering technologies to provide information to help customers to identify good load management opportunities, (b) storage technologies, and (c) load management systems to make load management as easy as possible for the customer.

Most likely near- and mid-term benefits from these PIER efforts will come from load management and metering technologies designed for the relatively sophisticated industrial market. These include activities such as the development of management and metering technologies to allow integration of accounts and management of load across multiple sites controlled by a company, and the integration of power generation and storage technologies for on-site industrial use.

Several activities are also designed to help manage peak loads in residential and commercial buildings. Planned activities include the development of low-cost real-time meters, the development of load management and load shifting technologies for building applications, development of low-cost storage technologies, and development of smart response technologies that will allow automated response of building energy systems to peak demand information. These efforts promise significant benefits to electric customers because of the importance of buildings to system peak loads.

Near-term benefits are most likely for larger commercial and multi-family buildings where loads and potential customer savings are large, so cost goals for acceptance of the technologies will be less challenging. The realization of significant impacts in smaller commercial buildings and single-family houses are likely only in the mid- to long-term because realization of acceptable technology costs and penetration into a less sophisticated market will be more challenging.

The benefits to both the industrial and buildings sectors will be increased by the development of methods to provide network signals over the power grid to alert customers and load management systems of the need for peak load reductions, and by studies to improve rate design by developing a better understanding of customer responses to alternative rates. PIER activities to achieve these goals will achieve benefits in the mid-term.

3.4.2.2.3 Enhance the Performance of the Transmission and Distribution System

California's transmission system has not been expanded in many years, and the transmission systems throughout the state are approaching maximum capacity during peak demand periods. Although the use of innovative supply technologies and the moderation of peak demand can improve electric reliability and reduce transmission and distribution congestion problems, improvements are also needed in the operational capabilities of the grid system itself to allow the effective integration of these technologies. The ability to improve reliability and reduce grid congestion need to be fully demonstrated and documented, and improved control, communications, and dispatch capabilities are also needed in order for the ISO to be able to control large numbers of distributed generators.

PIER activities to enhance the performance of the power grid include:

- Studies to identify weaknesses in distribution infrastructure,
- Technologies to detect and correct system failures,
- Identification of regulatory and technical options to manage network congestion, demonstration and documentation of the capabilities of widespread use of existing renewable and DG systems to bolster the operation of the distribution system, and development of new software, communications systems, and control systems to allow control of renewable and DG technologies by grid operators.

The creation and use of information by grid operators will begin to generate benefits in the near-term. Benefits will increase substantially in the mid-term if changes in grid operation show significant potential for improvements. Some benefits will be realized in the near-term, which will increase over time, through the deployment of DG and renewable technologies in strategic locations designed to bolster grid operation. In the mid- to long-term, the development and adoption of improved capabilities for grid operator control of DG and renewable systems will create large benefits.

3.4.3 Problem #3 – Balancing Electricity Needs with Protection of the Environment

The electricity system has a major impact on the environment—air, water, land use, habitat, greenhouse gases, and environmental justice—and pressure to increase supply, transmission and distribution could exacerbate these impacts in the future. The cumulative effects of generation, transmission, and distribution are not fully understood, and methods for predicting, measuring, and mitigating related adverse environmental impacts remain imperfect. Measures to increase the efficiency of energy use in buildings have, in some cases, adversely effected the indoor environment (indoor air quality), which in turn affects the health and safety of building occupants.

While California's current electricity system causes many adverse environmental impacts, electricity also holds the potential for improving some environmental problems (e.g., through increased use on new electro technologies which hold significant promise for purifying wastewater, disposing of agricultural, dairy and forest waste, and removing toxic chemicals from groundwater and soil). However, any effort to expand the electricity system will be constrained by existing, and increasingly stringent, environmental regulations, community activism, requirements for environmental justice, and possible global climate change protocols. In short, the need to balance electricity needs with protection of the environment is a major challenge, which California must address.

3.4.3.1 Cost if Environmental Problems are Not Addressed [54]

The Commission currently projects an increase in electricity demand in California to 310,000 GWh by 2010 and 378,000 GWh by 2020. These increases will require additional electrical generation, which will pose further environmental burdens in California. Virtually all new

---

[54] Analysis of the costs of not addressing California's electricity-related problems has been continuing during the development of this report. It is not yet complete at the time of the report, but results to date serve as the basis for cost estimates presented in this section.

generation capacity in California is currently expected to be provided by relatively clean natural gas-fired facilities. With this technology, additional air emissions are expected for CO and NOx. Neither of these emissions will have significant impacts on California air quality except for unusual local circumstances, but there will be increased competition between electric generators and other California industries for scarce emissions credits for NOx emissions, especially in Southern California. Costs have already gone as high as three to four cents per kWh equivalent. The increased cost associated with NOx emissions could have significant impacts on California industries, especially those that rely on boilers or process heating such as the food processing industry.

Water use for cooling of electric power plants in California is also expected to show a substantial increase as new generation is added, growing to 4.4 times 1995 levels by 2004 and to nearly 18 times 1995 levels by 2020. Although water consumption for power plants is not very significant compared with other uses of water, the environmental effects of power generation on water bodies can be significant, especially near the plants. For example, increases in stream temperatures downstream from thermal power plants that uses stream water for cooling can influence different species' capabilities to live in the stream, aquatic life can be killed by entrainment on screens that filter water coming into the cooling system, and chemicals that are used to protect the cooling system and that are released into the stream can threaten stream organisms. Further, hydroelectric facilities may also have significant ecosystem impacts including impingement and entrainment of organisms, blockage of fish movement and migration, fragmentation of ecosystems, and alteration of stream flows. These impacts are difficult to quantify, and have not been fully accounted for in current scientific analyses.

The relationship between emissions of greenhouse gases (primarily CO_2 and methane) and global climate change has become a very contentious international issue whose resolution could have a profound effect on the future fuel and technology choices for electrical generation. For example, proposals that resulted from an international conference on Global Warming and Greenhouse Gas Emissions at Kyoto would require a reduction in CO_2 emissions to a level seven percent below 1990 emissions by 2010-12.[55] Even greater reductions would be required to achieve a reversal of the rate of increase of greenhouse gas concentrations. We noted in the discussion of Problem #1 that mandated CO_2 emission reductions could make the construction of new fossil-fired power plants more costly and difficult. Similar problems would apply to other industries that use fossil-fueled boilers or process heaters. PIER will consider undertaking a study to estimate the potential costs and benefits to California from global climate change and the ramifications on the electrical system of possible actions to reduce emissions of greenhouse gases.

The construction of small renewable or natural gas-fired generators on-site at customer locations or at substation locations may be desired to improve the reliability and quality of electric power. However, just as it has become increasingly difficult to site new central station power plants, it will likely prove difficult to site small generators because of public protests over environmental impacts and equity concerns. The NIMBY phenomenon is well known, and

---

[55] Global Warming Policy: Some Economic Implications, NCPA Policy Report No. 224, National Center for Policy Analysis, March 1999.

the concept of environmental justice is now embodied in both federal and state law.[39] Further, available tools and data generally do not provide adequate information to characterize or to evaluate the localized environmental impacts from small generators, nor are there adequate methods and tools to develop rules for inter-pollutant, inter-basin or inter-credit emissions offset rules for such facilities.

The cumulative environmental impacts from multiple small sources are another concern related to small electric generators. Even where emissions are understood for individual small sources, the cumulative impacts from siting multiple sources in proximity to one another are not well known and are not addressed by current regulations. The aggregate impact of multiple sources may be significant even though none of these sources are, in themselves, significant emitters. Better tools and data are needed to determine the extent to which such cumulative impacts are important and merit regulatory attention.

3.4.3.2 Strategies to Address Electricity-Related Environmental Problems

We have discussed the challenges involved in meeting future expected growth in the demand for electricity under Problem #1 above. However, we believe that California's electricity system and protection of the environment can evolve into a new balance more favorable to each through the following PIER Program strategies: (1) improve the prediction, measurement, and mitigation of the environmental impacts of electricity supply, delivery, and end use; (2) integrate and improve the environmentally and economically beneficial supplies and uses of electricity; and (3) improve the prediction of global climate change on the electricity system and mitigate both the causes and consequences of global climate change.

3.4.3.2.1 Improve Prediction, Measurement, and Mitigation of Environmental Impacts

Air quality is already considered a serious problem in California, especially in the southern part of the state. Although increases in emissions from large gas-fired power plants is not expected to add significantly to air pollution problems, problems could be greater from additions of large numbers of small fossil-fueled plants. Some projections show significant future additions to generating capacity from small gas-fired plants, and there is some concern that existing backup diesel and gas-fired units will be pressed into service more frequently to meet growing electricity needs. Monitoring the impacts from these multiple small sources is a challenge to regulators and to their operators. The PIER Program will assist in efforts to improve the prediction, measurement, and mitigation of air impacts from such facilities.

Water quality impacts from hydroelectric facilities and from cooling systems for thermal electric plants are also a continuing concern. Chief among the concerns are ecosystem impacts from modification of stream flow, impingement and entrainment of organisms in plant cooling systems, and localized changes of temperature downstream from plants. Adding to the water quality concerns are uncertainties about how regulatory and ownership changes may change plant scheduling and lack of knowledge about possible cumulative impacts from multiple plants located in proximity to each other. The PIER Program can assist in efforts to improve the prediction, measurement, and mitigation of water-related impacts from such facilities.

Finally, indoor air quality is a growing concern in buildings. Emissions from furniture and building materials, molds and mildew, and airborne dust and microbes have long been recognized as concerns, and measures to improve the energy efficiency of buildings (such as tighter construction and reduced ventilation) have exacerbated these and other indoor air quality problems. There is an opportunity for the PIER Program to assist in mitigating indoor air quality problems by focusing on improvements in building design and operation that will increase occupant comfort and worker productivity while improving energy efficiency at the same time.

The PIER strategy to solve these electricity-related environmental problems consists of the following elements: (1) develop new science to support regulatory and policy decisions; (2) develop new models, measurement methods, and mitigation technologies to improve understanding of the impacts from electricity generation and ensure acceptable air and water quality controls; and (3) develop measurement technology, databases, design tools, and energy system commissioning and diagnostic tools to track and control the indoor environment.

Substrategy 1 to address electricity-related environmental problems: *Develop science to support regulatory and policy decisions.*

Sound regulatory policy that protects the environment while also allowing additions to electricity supply needed to support future demand growth requires timely data about the environmental impacts of supply alternatives. The PIER Program includes many activities designed to examine the crosscutting implications of applicable regulations and develop a science base to identify and evaluate potential impacts. Among the most important of these are the following:

- Development of basic data and tools to predict and verify the environmental performance of generation and distribution technologies
- Analyses of alternative policies (and possible offset trading rules) to encompass inter-basin, inter-credit, and inter-pollutant trading
- Analyses of policy options and regulatory approaches to guide environmental regulation of generators in a deregulated environment and to expedite fleet licensing of dg equipment
- Analyses of environmental performance of electricity generation under a deregulated market, and development of policy options (e.g. Environmental dispatch) to minimize environmental impacts
- Development of new regulatory policies and approaches to mitigate electricity-related environmental impacts in streams.

All of these activities involve primarily the development of information and analyses, and this substrategy will inform regulatory and policy decisions in the near-term.

Substrategy 2 to address electricity-related environmental problems: *Develop new information, models, measurement methods, and mitigation technologies to understand the impacts from electricity generation, transmission, and distribution and ensure acceptable air and water quality.*

In addition to support for imminent regulatory and policy decisions, the PIER Program will undertake activities to provide new data and better scientific understandings of mechanisms leading to environmental impacts from power generation, transmission, and distribution. Just as basic research in general is considered to be the seed corn for future applied research, the advancement of basic knowledge of pollutant transport, damage mechanisms, and possible cumulative effects from multiple sources and multiple pollutants will lead to the development of a better understanding of the ramifications of future regulatory and policy decisions.

Examples of air quality research areas in which basic knowledge is needed include the development of models to predict short-range air quality impacts from small fossil generators, contributions to long-range transport of PM and NOx by power plants, and the development of improved measurement approaches and tools to monitor the impacts of air toxics and criteria pollutants.

Key areas for new research with respect to water quality include the development of models to predict aquatic impacts of thermal power plants, models of direct and cumulative impacts of multiple hydro facilities on stream aquatic life and on down-stream and behind-dam sediment loading.

Other areas of research will include evaluations of the impacts of interactions between wildlife (primarily avian and bat species) and T&D systems, and land-use impacts (e.g., habitat fragmentation) from T&D rights-of-way and alternative energy resource development.

The PIER Program will also integrate its environmental impact research with the development of new technologies to mitigate impacts. For example, PIER will explore ways to further improve the performance of dry cooling systems or the use of degraded water for power plant cooling in place of fresh water. Some of the information produced as part of these efforts to advance environmental knowledge will be useful for near-term regulatory and policy decisions, but the bulk of the activities undertaken as a part of this substrategy will have mid- to long-term impacts by design.

Substrategy 3 to address electricity-related environmental problems: *Develop measurement technology, databases, design tools, and energy system commissioning and diagnostic tools to track and control the indoor environment.*

Concerns about indoor air quality have grown as energy efficiency improvements have resulted in reduced infiltration of outdoor air and reduced forced ventilation of buildings. Monitoring indoor air quality and minimizing undesirable indoor air quality impacts are important facets of continued movement toward more efficient building design and operation. By considering indoor environmental factors in the design of buildings and building energy systems, shell improvements can be implemented and high-efficiency equipment can be installed in a manner that will avoid undesirable impacts and improve the indoor environment. Such improvements will also increase occupant comfort and productivity. Finally, developing an awareness among electric customers of potential favorable indoor air quality impacts of some high-efficiency and renewable technologies can help in the promotion of these technologies and the realization of other desirable benefits that they provide (e.g., peak load reduction, reduction in ambient emissions, and reduction in dependence on natural gas).

Future PIER activities under this strategy include:

- Development of new building commissioning and diagnostic tools that enable building occupants to verify the environmental performance of energy systems

- Development of metrics, sensors, and controls the measure and minimize undesirable indoor air quality impacts from energy system operation
- Documentation of non-energy benefits, including increased productivity and comfort, associated with selected new energy technologies.

These activities will create significant benefits for electricity customers in the near-term, as no technology breakthroughs are required, and the realization of benefits involves primarily the dissemination of information.

3.4.3.2.2 Integrate and Improve Environmentally Beneficial Supplies and Uses of Electricity

Californians have consistently demanded increased efforts to improve or maintain the natural environment, and there is no sign that this trend is changing. The PIER Program will pursue several important RD&D substrategies in this regard, namely (a) development of new technologies, design tools, and construction methods for buildings that address energy and economic needs while ensuring occupant safety and improvement of the indoor environment; (b) development of advanced, small electricity generation technologies that are cleaner than existing technologies and cost-competitive; and (c) advancement of new energy-efficient solutions to public health and environmental problems at end-use sites.

Substrategy 1 for environmentally beneficial electricity supply and use: *Develop new technologies, design tools, and construction methods for buildings that address energy and economic needs while ensuring occupant safety and improving the indoor environment.*

Building design, construction, and operation directly affect occupant comfort, productivity, and health. Heating, cooling, lighting, humidity control, and ventilation all have obvious effects on occupant comfort and productivity, and efforts to reduce building energy use by changing any of them can impact comfort and productivity. However, the careful design of buildings and related energy systems can reduce or eliminate undesirable changes in comfort level as a result of efficiency improvements. Similarly, human health can be affected by building design and operation, particularly ventilation and humidity control.

The PIER Program will fund efforts to improve building design and construction techniques to minimize negative impacts on the indoor environment while increasing energy efficiency. These efforts will include:

- Modification of building simulation models and design guidelines to take into account considerations unique to California
- Improved building and equipment design and operation approaches to increase occupant productivity while also increasing energy efficiency
- Development of new technologies and practices to simultaneously improve efficiency and the indoor environment. Low income and multifamily housing are a particular challenge with respect to both the efficiency and indoor air quality objectives, and some PIER activities will focus specifically on their unique considerations.

Some benefits may be seen in the near-term as a result of recommended changes in operations of existing buildings, but most benefits from activities comprising this substrategy will be seen in the mid- to long-term because of the time required for a significant turnover of the building stock.

Substrategy 2 for environmentally beneficial electricity supply and use: *Create advanced, small electricity generation technologies that are cleaner than existing technologies and cost-competitive.*

Although electric power generation based on natural gas is relatively clean, emissions of CO and NOx from these plants still contribute to overall statewide emissions. The development of cost-competitive advanced generating technologies that are cleaner than current technologies will remain an important element of the PIER Program. PIER activities to accomplish this goal are planned for three specific areas, namely: (a) development of advanced fossil-fired small generation technologies such as fuel cells or ultra low-emission gas turbines, (b) development of technologies and concepts to support a hydrogen-based energy economy, and (c) development of improved renewable technologies. In the renewables area, we will pursue important opportunities to integrate these technologies with other societal goals. Specific synergistic opportunities include the use of renewables to solve problems at environmentally-sensitive locations, and the integration of biomass technologies into disposal strategies for forest products, urban wood wastes, or other similar by-products.

Most PIER activities for this substrategy will provide mid to long-term benefits to electricity customers. However, there will be some near-term payoffs where renewables technologies help to achieve more environmentally acceptable disposal of waste products.

Substrategy 3 for environmentally beneficial electricity supply and use: *Provide advanced, energy-efficient solutions to public health and environmental problems at end-use sites.*

The operation of electric technologies to supply industrial energy or process needs often causes significant environmental or public health impacts. The PIER Program will fund activities as follows:

- Improve existing industrial technologies and develop new technologies to minimize any undesirable impacts (e.g., advancements in food processing technologies (such as food storage technologies), improvements in temperature control and monitoring systems, and development of environmentally benign fumigation technologies.
- Integrate waste management systems for agriculture and dairy applications with biomass energy systems (thereby reducing overall pollution and adding value where there was only cost before).
- Maintain a supply of clean water through improved treatment technologies that minimize contamination of groundwater and streams, water recycling approaches that maximize the utility from a volume of water (e.g., recycled water for landscape use), and advanced treatment technologies to increase the supply of clean water.

Benefits from efforts to make incremental improvements in existing industrial energy and process technologies will begin to accrue in the near-term while the development of advanced water treatment and integrated biomass/waste disposal technologies will show benefits in the mid- to long-term.

3.4.3.2.3 Improve Prediction and Mitigation of Global Climate Change Impacts on the Electricity System of California

The potential for global climate change from the buildup of the greenhouse gases (GHGs, principally CO_2 and methane) in the atmosphere, the magnitude and rate of the potential change, and the appropriate responses to the potential change have proven to be highly contentious issues. The efforts to reach international political agreements that specify national actions (or goals) to reduce the rate of increase of GHGs in the atmosphere have not been successful in spite of many years of effort worldwide. The reason a consensus of nations has not been achieved on this issue is that the economic consequences of different response strategies (including the no-response strategy) vary widely from region to region and from nation to nation.

As the nature of a future agreement is impossible to predict with any certainty at all, the wise course of action for California is to learn more about the potential climate change impacts for California and to prepare options that will allow this state to respond to various political outcomes. In a general sense, PIER efforts to promote higher energy efficiency and renewable energy options will also help to prepare California for any outcome with respect to GHG agreements. More specifically, PIER will undertake model development or refinement and scenario analysis to identify the impacts of various possible international agreement outcomes and to identify possible mitigation and adaptation strategies to minimize the costs for California. This work by nature will have primarily long-term impacts.

3.4.4 Problem #4 – Market Uncertainty and Price Volatility are at Unacceptable Levels

Price uncertainty and volatility are currently occurring at unacceptable levels in California's electricity market because of a number of factors including the structure of the current electricity market, reduced availability of natural gas, the very tight emission trading allowances and the growing demand for electricity.[56] The electricity market in California is presently operating in a manner that creates serious financial risks for suppliers, utilities, and end-users alike. Financial markets view these risks unfavorably, and this, in turn, could adversely effect capital availability for expensive new generating facilities and contribute further to the extraordinary electricity price volatility and episodes of sustained high prices in this state.

Elevated prices and uncertainty are due, in part, to the number and the complexity of the electricity markets that currently make up the deregulated electricity environment in California. The number of separate markets operated by the PX and the ISO, the complexity of their designs, the interactions between each market, the financial participation requirements of each market, and the infrastructure necessary to participate in these markets limit participation to a small number of well-financed, sophisticated organizations.

Market rule changes are another factor in creating price uncertainty. Changes in rules in one market result in changes in other markets. This action has also led to the number of electricity

[56] Price volatility for the electricity consumer is also driven by high demand, particularly during periods of peak electricity use. These issues have been described in detail in Problems #1 and #2, above, and will not be discussed further here.

market transactions handled by the ISO growing exponentially, straining the communications, control, and dispatching capabilities of the ISO.

Additional factors creating price uncertainty for all participants in the electricity markets are the cost and availability of natural gas and NOx RECLAIM Trading Credits (RTCs). Natural gas is now the preferred fuel for major new electricity generation in California and in the rest of the U.S. High spot prices for natural gas (e.g., $30 per million Btu occurred in California in December 2000) can push power plant generating costs to more than $225 per MWh for fuel alone. For older plants in the South Coast Air Quality Management District, NOx RTC prices can add another $50 / MWh. Taken together these trends leave Californians vulnerable to increasing price volatility and very high prices in both the electricity and the natural gas markets.

3.4.4.1 Cost if Market Uncertainty / Price Volatility Problems are Not Addressed [57]

Recent changes in the electricity market, coupled with abnormal weather conditions and continued strong economic growth, have induced extreme electricity price volatility that began in the summer of 2000 and continue into 2001. A combination of circumstances in the summer of 2000 (e.g., growing peak loads, unscheduled power plant outages, and competition for capacity with other regions) led to major electricity cost increases for California customers. For example, in the summer of 2000, the wholesale price of electricity paid by the San Diego Gas and Electric Company ranged between 10.7 cents and 21.4 cents per kWh. The additional cost paid by SDG&E customers during the summer, compared to rates paid in the summer of 1999, was about $4.3 billion. In August alone, California ISO customers paid $4.1 billion for electricity, about four and one-half times the cost for August of 1999. Approximately half of this increase has been estimated to be associated with higher generating costs and half to the exercise of market power by electricity marketers. If the present trend of growing peak loads and slower growth of capacity additions is not reversed, the events of summer 2000 will be repeated more frequently in the future. Customers will pay higher bills and will be subject to electricity price uncertainties that make it difficult for small customers to budget and for larger customers to compete economically.

Higher electricity price and electric bill uncertainties are not the only costs that will be incurred by California electricity customers in the future. During the year 2000, there were 55 Stage 1 Emergencies, 36 Stage 2 Emergencies, and one Stage 3 Emergency. As discussed earlier in connection with Problem #2 (peak demand), these uncertainties will result in increasing expenditures by California industries in backup systems and power conditioners to maintain needed reliability and power quality (projected to be $4 billion / year by 2004). Furthermore, the uncertainties as to whether electric power will be available when needed could dampen the growth of California industries and may result in the erosion of the existing industrial base, leading to job losses, payroll reductions, and the loss of exports.

---

[57] Analysis of the costs of not addressing California's electricity-related problems has been continuing during the development of this report. It is not yet complete at the time of the report, but results to date serve as the basis for cost estimates presented in this section.

Adding to the uncertainties of electricity supplies in California is the growing dependence of California on natural gas for power generation. Unless additional gas pipelines are built to supply gas to California, natural gas supplies could be inadequate by 2009. Gas prices as well as electricity prices will rise as gas becomes more difficult to obtain. California industries and consumers will be effected by uncertainties in their gas bills and gas supplies as well as their electricity bills and supplies. This uncertainty will add to the likely dampening of the growth of the California economy.

3.4.4.2 Strategies to Address Electricity Market Uncertainty and Price Volatility

3.4.4.2.1 Improve the Understanding of California's Energy Market Structure and Rules

The electricity system in California is currently undergoing a major transition from a fully regulated market to a substantially deregulated market and, perhaps to a re-regulated market. Many of the rules—formal and informal—that currently govern this market may not be operating to ensure efficient and equitable results. One indication of problems with current electricity market rules is the extreme volatility of electricity prices. (**Figure 7** illustrates the recent high volatility of the electricity market, as shown by the daily market clearing price for electricity processed through the California Power Exchange between January 1, 1998 and December 31, 2000.)

This extreme price volatility is exacerbated by, and in part explained by, the fact that electricity demand tends to be very inelastic in the short-term. That is to say, significant increases in price produce negligible reductions in demand. For example, during December 2000, when the peak price of electricity shot up by 450 percent (from about $250 / MWh to about $1400 / MWh), the lowest daily peak load was only about 37 percent lower than the highest daily peak load (20,000 MW versus 32,000 MW).

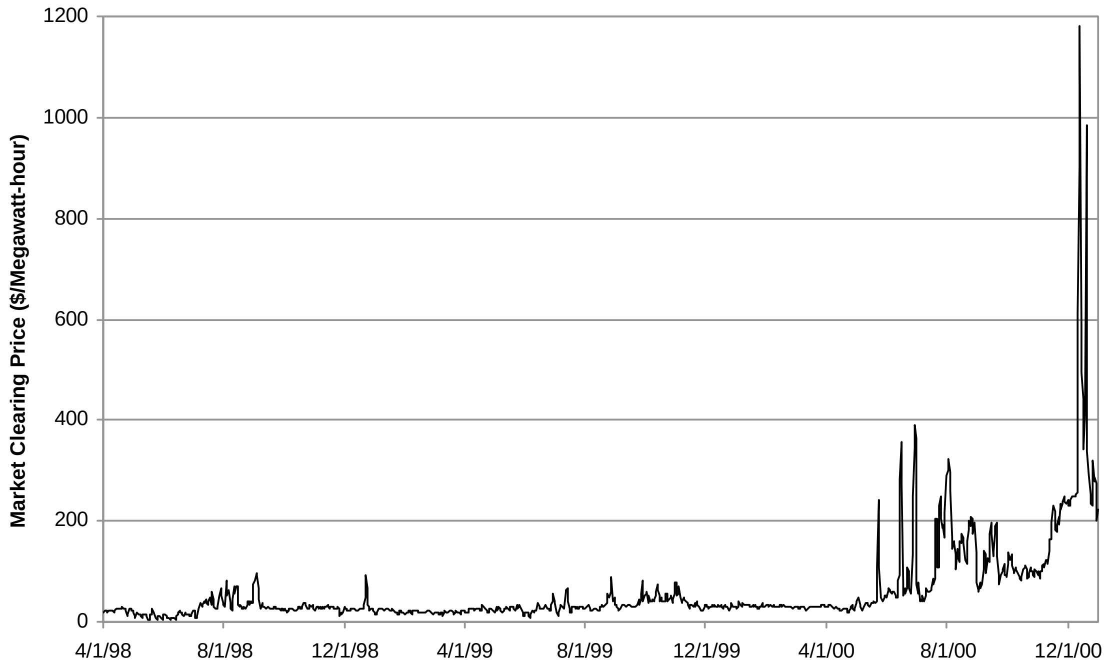

Figure 7. Daily Market Clearing Price for Electricity at the California Power Exchange

Source: Unconstrained Market Clearing Prices and Quantities in PX Day-Ahead Market, University of California Energy Institute web site, <http://www.ucei.berkeley.edu/ucei/datamine/px_umcp.html>.

The PIER Program can assist in developing a better understanding of how existing electricity markets work, and where there are opportunities to improve the rules and regulation of the market in California. As this better understanding of the market emerges, PIER can also develop recommendations for appropriate changes in market rules and regulations, including increased investment in technology innovations, increased customer choice concerning electricity service attributes and technologies, more diversity in generation fuel mix, and more flexibility in managing and mitigating environmental emissions and impacts.

These activities will produce benefits as a better understanding of electricity markets is developed and communicated to market participants and regulators, and initial benefits should be felt in the near-term and continue into the mid- and long-term, as the California market matures.

3.4.4.2.2 Decrease Demand

Market uncertainty and price volatility can be moderated somewhat by improving end-use efficiencies in California so that less energy is needed to provide the desired level of service. The planned PIER activities to implement this strategy are described in detail under Problem 1.

3.4.4.2.3 Match Supplies More Closely to Demand

The planned PIER activities to implement this strategy are described in detail under Problem 1.

3.4.4.2.4 Provide Consumers with Better Information, Decision Tools and Energy System Components

The planned PIER activities to implement this strategy are described in detail in Problem 1.

Chapter 4 — Responses to Specific Legislative Directives in SB 1194 and AB 995

4.1 Legislative Requirements

This chapter responds directly to certain legislative requirements contained in SB 1194 and AB 995, as enacted in 2000. Specifically, funding for the PIER Program has been extended for 10 years (2002 through 2011), and Public Utilities Code Section 399.7(b) now directs that:

> Notwithstanding any other provision of law, moneys collected for public-interest research, development and demonstration pursuant to this section shall be transferred to the Public Interest [Energy] Research, Development and Demonstration Fund of the Energy Commission to be held until further action by the Legislature. The Energy Commission shall prepare and submit to the Legislature, on or before March 1, 2001, an initial investment plan for these moneys, addressing the application of moneys collected between January 1, 2002, and January 1, 2007. The initial investment plan shall address the recommendations of the PIER Independent Review Panel Report, dated March 2000, to either transform the RD&D program within the Energy Commission or to administer it through, or in cooperation with, an external organization. The initial investment plan shall include criteria that will be used to determine that a project provides public benefits to California that are not adequately provided by competitive and regulated markets …

In the following sections of this chapter, we list the initial five-year investment plan (and related budget) for the moneys collected between January 1, 2002, and January 1, 2007. Thereafter, we identify the criteria that will be used to ensure that RD&D projects funded through the PIER Program provide public benefits to California that are not adequately provided by competitive and regulated markets. Finally, we address the recommendations of the PIER Independent Review Panel Report, dated March 2000, to either transform the RD&D program within the Energy Commission or to administer it through, or in cooperation with, an external organization.

4.2 PIER's Five-Year Investment Plan Budget for 2002 Through 2006

PIER's budget for 2002 through 2006 reflects California's energy policies, problems, and the RD&D solutions discussed previously in this report. By its very nature, the budget strives to maintain continuity for research solutions concerning major energy problems currently confronting California *while at the same time* retaining adequate flexibility to address unanticipated changes in California's future research priorities.

This investment budget is not expected to produce *immediate* solutions to California's current electricity crisis because RD&D programs generally tend to produce benefits on a longer-term basis. However, it can and is expected to reduce this state's future electric system problems associated with demand exceeding supply, unnecessarily high costs, unreliable service, over-reliance on limited fuels and unnecessary environmental impacts. All of these factors are at the heart of the current crisis and are addressed in this plan.

The PIER Program will adopt a portfolio approach to effectively balance the risks, benefits to ratepayers, and time horizons for various PIER activities and investments. All PIER research priorities will be approved by the PIER Program Manager and the Commission's RD&D Committee based upon emerging opportunities, shifts in important electricity system problems, and the benefits derived from prior projects in each subject area. This will ensure that the PIER Program develops solicitations and funds projects that provide the most significant benefits to the citizens and ratepayers of California.

Funding will be allocated to:

1. Advance science and engineering for a diverse range of technologies.

To support diverse technologies, PIER has Team Leads and support staff to manage and guide projects in the following technical subject areas:

- Buildings End-Use Energy Efficiency
- Industrial / Agricultural / Water End-Use Energy Efficiency
- Renewable Energy
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Energy Systems (Strategic) Research (including transmission, distribution and storage)

Areas requiring research and funding include the following: renewable and natural gas technologies; innovative efficient end-use applications in buildings, industry, agriculture, and appliance technologies; advances in transmission, distribution, storage, and conversion technologies; and enabling technologies, such as advanced sensors and information systems. Finally, we will maintain a robust environmental component to apply a scientific basis for evaluating and mitigating the impact of energy technologies and to apply energy technologies to environmental problems in ways that save energy.

To facilitate planning, Team Leads will be allocated funding for a two-year period. The allocation will be based on how their objectives and metrics contribute to the overall program.

2. Address different time frames for impact on the market, and different challenges along the RD&D spectrum.

Maintaining and enhancing a balanced portfolio of technologies in various stages of development is critical because of the complexity of the problems facing California. RD&D activities will range from feasibility studies on new, longer-term energy concepts, to applied research, to technology development, to demonstrations. Some of the PIER Program's near-term projects could be commercialized and provide benefits by 2002 while many other successful projects will provide benefits over the course of the next decade. We will also fund some higher risk research that has the potential for significant breakthroughs in the long-term.

RD&D projects that will start to have an impact on the market in less than five years are considered to be *near-term*. (Some near-term projects, such as studies for policy-makers, may even provide tangible benefits within a year or so of completion). *Mid-term* projects are expected to start having an impact within approximately 5 to 15 years, and *long-term* projects may take 15 years or more to provide tangible impacts.

Most of the strategies and activities described in Chapter 3 will lead to projects with initial impacts on the market in the near- and/or mid-term timeframes. But it is important for the PIER Program to devote a portion of its available funding to the assessment and incubation of long-term opportunities, with the prospect of developing breakthrough concepts that could be paradigm shifting. Accordingly, PIER has allocated and will continue to allocate $2.5 million annually for a Small Grants Program (within the Strategic Energy Research subject area) to fund feasibility studies on new, longer-term energy concepts. Maximum funding for individual grants is limited to $75,000, and new proposals are solicited every quarter.[58]

3. Fund integrated solutions for major energy problems.

Integrated activities have the potential to produce enhanced benefits through their synergies and coordination within PIER and with other RD&D Programs. PIER will seek to leverage its funds with co-funding or in-kind contributions from other private, regulated, or public sector participants. These efforts will be coordinated with market participants and other public goods programs to ensure that the results reach the market as quickly and efficiently as possible.

To reduce the risk that RD&D results will not reach the market and produce benefits, some PIER solicitations require a "programmatic" approach to solving problems. This means that bidders must propose a linked set of RD&D projects employing a mix of technologies that address a common barrier or seek a common goal. To accomplish this, bidders must use a team of expert participants who will work across organizational and institutional boundaries to implement complete solutions, including market entry.

Summarized below from Chapter 3 are the four major energy problems confronting California, and the strategies adopted by PIER for addressing the problems and finding solutions.

Strategies for Problem #1 - Electricity Demand is Increasing Faster than Supply.

- Increase supply.
- Decrease demand.
- Match supplies more closely to demand.
- Provide better information, decision tools and energy system components.

Strategies for Problem #2 – Rising Peak Demand Threatens Reliability.

- Increase the utilization of local generation technologies.
- Reduce peak demand and/or shift peak demand to off-peak periods.
- Enhance performance of the transmission and distribution system.

Strategies for Problem #3 – Balance Electricity Needs with Protection of the Environment.

---

[58] Thus far, the PIER Small Grants Program has received approximately 30-40 proposals per solicitation, of which 3-4 have been funded each quarter.

- Improve the prediction, measurement, and mitigation of environmental impacts of electricity supply, delivery, and end uses.
- Integrate and improve environmentally beneficial supplies and uses of electricity.
- Improve the prediction of global climate change and related influences on the electricity system, and mitigate both the causes and consequences of global climate change.

Strategies for Problem #4 – The Market Structure, Fuel Shortages, Emission Allowances and High Peak Demand Produce Market Uncertainty and Price Volatility.

- Improve the understanding of California's energy market structure and rules.
- Decrease demand.
- Match demand more closely to available supplies.
- Provide better information, decision tools and energy system components.

The five-year investment budget for the PIER Program must balance the competing objectives of addressing the four major energy problems facing California, maintaining flexibility to respond to the unpredictable changes that are likely to occur, and adhering to the criteria described above. This will be done by (1) dedicating a minimum of $165 million (approximately one-half of the funds available over the five years) to implementing the various strategies designed to address the four problems **(Table 4)** and (2) reserving the remaining available funds (approximately $147.5 million over five years) to be competitively allocated to specific activities and strategies based on their expected public interest benefits.

Table 4. PIER Program Budget for 2002 through 2006

Electricity Problems of Highest Concern in California	Five-Year Budget ($ millions)
1. Electricity demand is increasing faster than supply.	$50
2. Rising peak demand threatens reliability.	$50
3. Balance is needed between electricity and the environment.	$50
4. The market structure, fuel shortages, emission allowances and high peak demand produce market uncertainty and price volatility.	$15
Dedicated five-year budget	$165
Reserved five-year competitive budget	$147.5
Total five-year budget @ $62.5 million per year	$312.5

NOTES: (1) For the remainder of 2001, the PIER Program will continue to follow the existing PIER Strategic Plan with actual RD&D activities that are consistent with the comments received by both the Policy Advisory Council and the Independent Review Panel.

(2) Initially, Problem #4 will be funded at a lower level than the other three problems because its strategies overlap those for Problems #1 and #2, and other strategies and activities to address this problem may be less amenable to RD&D solutions.

Funds will be allocated based on the roadmaps to be developed for each area and on overall program goals. These roadmaps will contain criteria for project selection and a set of metrics to gauge project and program impacts. The Program Manager will retain funds that will be allocated to subject areas as new opportunities are identified. This approach provides an appropriate mix of focus and flexibility for meeting program goals.

4.3 Flexibility in Budgeting

The funding process must remain flexible as the relative importance of issues change. The reasons for flexibility include the following:

- Research and development efforts may shift funding from some areas to others that have greater potential for success.
- The emergence of new, unforeseen concerns. For example, PIER has not specifically addressed transmission and distribution issues under AB 1890. This is now an area of considerable importance.
- Increased funding by another institution or agency may allow us to re-allocate scarce resources.
- Successful commercialization of technologies will eliminate the need for further PIER funding in these areas.
- Periodic review to determine which areas should receive increased funded and to discover emerging research and technology ideas.

4.4 Technology Partnerships

California possesses the intellectual and institutional resources to help meet the state’s energy challenges. The PIER Program will foster closer ties with the University of California, California State University, California's Environmental Protection Agency and Trade and Commerce Agency. Success requires that we develop and maintain effective and mutually rewarding relationships with industry—both technology users and providers—and institutions that commercialize technologies.

Further, the PIER Program will develop and enhance technology partnerships with the U.S. Department of Energy, particularly with the Office of Energy Efficiency and Renewable Energy. We will focus on California-specific problems (and, if possible, frame the debate for overall program direction) with the Offices of Power Technology, Industrial Technology, and Buildings Technology. We plan to work with both the Office of Fossil Energy on selected projects and the Office of Science on selected areas of environmental research.

In addition, we intend to work closely with national research organizations, such as the Electric Power Research Institute, the Gas Technology Institute, and with other states and their energy research organizations (e.g. the New York State Energy Research and Development Authority) on problems of mutual interest.

4.5 Response to the PIER Independent Review Panel’s Preliminary Report

In its Preliminary Report to the Governor and Legislature dated March 2000, the PIER IRP agreed that the PIER Program has many strengths and is sponsoring a number of high-quality RD&D projects. However, the IRP also noted unless it is significantly transformed, PIER may not become a truly outstanding research and development program that will benefit the citizens of California.[59] The IRP went on to recommend that the PIER Program be continued but be transformed into a new organizational environment, either inside or outside the Commission, that would provide the legal and organizational basis for a superior public interest energy RD&D program.[60] The panel chose not to evaluate in detail the pros and cons of various organizational arrangements but agreed unanimously on the characteristics necessary for an outstanding program. The IRP also identified several specific issues that needed to be addressed if the PIER Program is to become the truly outstanding research program that was envisioned.

Following the release of the IRP's Preliminary Report, the Energy Commission's RD&D Committee and staff entered into a constructive discussion with the IRP regarding the best means for responding to these issues. It was agreed that the issues could be grouped into three categories of concern: (1) Leadership and Management of the program, (2) Policy and Planning for the program, and (3) Administrative Streamlining of the program. Accordingly, last spring the Commission assigned staff members to address the IRP's concerns in these three areas, and in June of 2000 the IRP formed specific subcommittees to coordinate directly with the staff in each of these areas. Based on the numerous discussions with these subcommittees, the Commission has undertaken a number of significant activities throughout the past several months aimed at strengthening the entire PIER Program, with particular emphasis on the areas of concern raised by the IRP.

With the significant improvements that have been and are being incorporated, the Commission continues to believe that it is in the best interest of the citizens of California for the administration of the PIER Program to remain within this Commission. While certain improvements are still need in some areas, such as contracting and staffing, the program as a whole is now well positioned to be carried out efficiently and effectively under the Commission's auspices. Listed below is the current status of the Commission's efforts and progress to date, and the remaining activities to be completed in the months ahead for each of the three categories of concern.

4.5.1 PIER Leadership and Management

4.5.1.1 Progress to Date

Last fall, the Commission decided that effective management of the PIER Program required a fundamental organizational change within the agency. Accordingly, the program will reside within its own Division at the Commission, and the PIER Program Manager reports directly to the Executive Director of the Commission.

The PIER Program Manager directs the work of dedicated staff members, who will be responsible for *all* of the Commission's electricity RD&D activities, including the current surcharge-funded PIER Program. Given difficulties in hiring a sufficient number of technically knowledgeable staff, creative mechanisms will need to be used to achieve a critical mass of

---

[59] Independent PIER Review Panel Report, March 2000, page 2.

[60] Ibid.

technical expertise for effective program operation. There are seven PIER units within the new division, with the following subject areas of responsibility:

- Residential and Commercial Buildings End-Use Energy Efficiency
- Industrial / Agricultural / Water End-Use Energy Efficiency (Process Energy)
- Renewable Energy Technologies
- Environmentally Preferred Advanced Generation
- Energy-Related Environmental Research
- Energy Systems (Strategic) Research
- Integration and Evaluation (including RD&D memberships, administrative streamlining, information management, technical support and program administration).

The Commission has hired a new Program Manager, Terry Surles, from Lawrence Livermore National Laboratory to lead the PIER Program. This has been achieved through an interjurisdictional exchange with the University of California.

Each of the six PIER subject areas now has a *permanent* Team Lead assigned on a full time basis. These leaders are as follows:

- Nancy Jenkins (Residential and Commercial Buildings End-Use Energy Efficiency)
- Pramod Kulkarni (Industrial / Agricultural / Water End-Use Energy Efficiency)
- George Simons (Renewable Energy Technologies)
- Mike Batham (Environmentally-Preferred Advanced Generation)
- Kelly Birkinshaw (Energy-Related Environmental Research)
- Laurie ten Hope (Energy Systems [Strategic] Research).

4.5.1.2 Expected Future Progress

The PIER Program Manager will continue to review and clarify the roles and responsibilities of various agency participants in the PIER Program. The PIER Program Manager, in conjunction with the Commission's Executive Director and the Commission's RD&D Committee, will finalize and implement a clear and complete description of the roles and responsibilities for everyone working on the PIER Program, including the Commissioners, the administrators, and all assigned staff.

4.5.2 PIER Policy and Planning

4.5.2.1 Progress to Date

In early April 2000, the staff presented to the RD&D Committee a proposed framework, schedule and report outline for future PIER policy, planning, and program evaluation efforts. The objective was to outline a methodology for producing an Integrated PIER Plan, with related budgets. This framework called for a plan that identifies California context issues, identifies those areas where public interest research could be of value, and then develops an integrated methodology for prioritizing funding allocations across the various PIER subject areas. The RD&D Committee approved the proposed integrated planning framework, and directed the staff to develop a specific step-by-step methodology for implementing this approach. The staff-developed, integrated planning methodology is designed to identify the problems of highest concern to California that the PIER Program must address. This approach has been embodied in the development of this Five-Year Investment Plan, which the IRP has reviewed and commented upon.

4.5.2.2 Expected Future Progress

The development of a series of roadmaps which will allow for a more complete benefit/cost analysis process, including program evaluation metrics, for the Investment Plan will be completed during 2001.

4.5.3 PIER Administrative Streamlining

4.5.3.1 Progress to Date

On March 29, 2000, the staff submitted a detailed analysis to the RD&D Committee entitled *Further Streamlining the PIER Contracting Process*. This report identified streamlining accomplishments and opportunities in each of the three major parts of the PIER contracting process: project selection, project contracting, and project management. After discussing its findings with the RD&D Committee, the staff began developing a specific plan for addressing the issues identified in the report. A proposed implementation plan was presented to the RD&D Committee in late May.

In June of 2000, implementation activities were expanded to include direct coordination with the IRP subcommittee assigned to Administrative Streamlining. The coordinated Commission-IRP team met twice in July and reviewed all of the administrative streamlining issues contained in both the IRP's March Report and the staff's March Report. Among other things, the coordinated Commission-IRP team clarified which issues are properly within the administrative streamlining area, and issues that will be handled by other PIER teams and IRP subcommittees.

On July 13, 2000, the Commission's Executive Director officially assigned the staff responsible for carrying out this administrative streamlining matter. Since August 2000 the PIER Administrative Streamlining Team has focused on the following issues:

1. Reduce the total amount of time from the issuance of an RFP to starting work on an executed contract.

The goal is to reduce the average time it takes to complete this multi-phased process from more than nine months to four months and to be more consistent across all funded projects. (Several changes have already been made in the recently held solicitations that improve the process. For example, RFPs now include more specific instructions on the formats for work statements and budgets, current contract managers are participating more directly in the review and selection of the proposals, and the Commission has completed a Competitive Negotiation Solicitation that enables more interaction between the contractor and the Commission during the selection phase of the process). This four-month goal has been met in all recent solicitations.

2. Develop agreements that have the flexibility needed for research projects, yet still have appropriate levels of accountability.

Significant strides have already been made in this area. For example, PIER contracts now allow task level changes to occur without specific approval of the Commission unless there is a significant change in the scope of the work or the goal of the project has changed. Based on direction from the RD&D Committee, the focus since August 2000 has been on membership or collaborative-funded agreements. This effort involved working closely with the Department of General Services (DGS) to develop clear guidelines for these agreements. An examination of the research and administrative benefits that would result from using grants instead of contracts was also completed. Again, through discussions with DGS, it has been determined that some of the RD&D that PIER funds could be funded through grants. The first PIER research grant was approved on December 20, 2000. More are likely. The final determination of how to decide between a grant and contract will be completed by the end of March 2001.

3. Improve the consistency and quality of contract management.

PIER contracts have several features, including flexibility, which are different from other contracts in the Commission. The biggest issue is to ensure that all staff working on PIER contracts receive training in how to properly manage and implement these features. We have completed a document describing the preparation of a final report that has proved useful to contractors and contract managers who are closing out their contracts. In conjunction with this document, we have also established an efficient and effective procedure for putting the final reports into a readable format. (Staff resource limitations have made it necessary for only three core team members to work on all contract packages, and at the same time to complete the development and implementation of documents and a process to produce clear and complete contract packages on time. The documents and procedure will be inserted into future RFPs.)

4.5.3.2 Expected Future Progress

We have not yet completed all portions of the tasks that were identified by the subcommittee in August 2000. These are discussed below:

1. Develop agreements that have the flexibility needed for research projects, yet still have appropriate levels of accountability.

The staff will evaluate the work statements of several other research organizations (such as EPRI, GTI, New York State Energy Research and Development Authority (NYSERDA), and University of California) to see if they have more suitable processes that can be adopted. Additional changes to our legislative mandate may be necessary to better implement contract streamlining.

2. Improve the consistency and quality of contract management.

The staff will develop clearer roles and responsibilities for everyone involved in PIER contracts, and will establish an annual review of all projects receiving PIER funds to determine whether funding should continue.

3. Establish an on-going mechanism to improve the PIER contracting processes.

The staff will identify process targets and metrics for determining contracting effectiveness. With this in place, the staff will then be able to evaluate and compare performance based upon these metrics on a regular basis and make improvements accordingly.

Glossary

AB	Assembly Bill
ADL	Arthur D. Little, Inc.
CARB	California Air Resources Board
CHP	Combined heat and power
CO	Carbon monoxide
CO_2	Carbon dioxide
Commission	California Energy Commission
CPUC	California Public Utilities Commission
DER	Distributed energy resources
DG	Distributed generation
DGS	California Department of General Services
DOE	U.S. Department of Energy
EOB	California Electricity Oversight Board
EPA	U.S. Environmental Protection Agency
EPAG	Environmentally Preferred Advanced Generation (PIER subject area)
EPRI	Electric Power Research Institute
GCC	Global climate change
GHGs	Greenhouse gases
GRI	Gas Research Institute
GSP	Gross State Product
GTI	Gas Technology Institute (formerly GRI)
GWh	Gigawatt-hours (10^9 watt-hours = 10^6 kilowatt-hours)
IAW	Industrial / Agricultural / Water End-Use Energy Efficiency (PIER subject area)
IRP	PIER Independent Review Panel
ISO	California Independent System Operator
kWh	Kilowatt-hours (10^3 watt-hours)
lbs/day	Pounds per day

Mgal/d	Million gallons per day
NIMBY	Not in my backyard
NOx	Oxides of nitrogen
NREL	National Renewable Energy Laboratory
NYSERDA	New York State Energy Research and Development Authority
ORNL	Oak Ridge National Laboratory
PIER	Public Interest Energy Research
PM	Particulate matter
PM10	Particulate matter with size less than 10 microns
POWER	Program on Workable Energy Regulation
PX	California Power Exchange
RD&D	Research, development and demonstration
SB	Senate Bill
SWRI	Southwest Research Institute
TWh	Terawatt-hours (10^{12} watt-hours = 10^{9} kilowatt-hours)
UC	University of California
WERF	Water Environment Research Foundation